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THE DESIGN CONSTRUCTION AND MAINTENANCE OF NAVAL FIXED OCEAN FA--ETC(U)
AUG 77 T J ANDERSON, R NORTON, W F HILL N62477-73-C-0359
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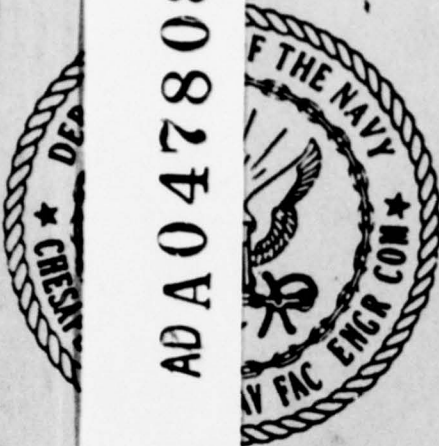
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**FIXED OCEAN FACILITIES
SUSPENDED CABLE
STRUCTURES**

**FPO-I-77(20, Vol.4)
AUGUST 77**

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| ORIGINATING ACTIVITY (Corporate author) | | 2a. REPORT SECURITY CLASSIFICATION | | | | | | | | | | | | | | | | | | | |
| Ocean Engineering & Construction Project Office Chesapeake Division, Naval Facilities Engineering Command, Washington, D.C. 20374 | | UNCLASSIFIED | | | | | | | | | | | | | | | | | | | |
| REPORT TITLE | | 2b. GROUP | | | | | | | | | | | | | | | | | | | |
| ⑥ The Design Construction and Maintenance of Naval Fixed Ocean Facilities: Volumes 4, Fixed Ocean Facilities, Suspended Cable Structures | | | | | | | | | | | | | | | | | | | | | |
| 4. DESCRIPTIVE NOTES (Type of report and inclusive dates) | | | | | | | | | | | | | | | | | | | | | |
| 5. AUTHOR(S) (First name, middle initial, last name) | | | | | | | | | | | | | | | | | | | | | |
| Vol. 1 Marine Systems Division, Rockwell International Corp. Vols. 2, 3, 4, & 5 Ocean Systems Comp. Lockheed Missiles & Space Co. <i>Inc. Sunnyvale, CA</i> | | | | | | | | | | | | | | | | | | | | | |
| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS | | | | | | | | | | | | | | | | | | | |
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| 8a. CONTRACT OR GRANT NO. | 8b. ORIGINATOR'S REPORT NUMBER(S) | | | | | | | | | | | | | | | | | | | | |
| N62477-73-C-0359 MODP00008 <i>new</i> | ⑩ T. J. / Anderson, R. / Norton W. F. / Hill | | | | | | | | | | | | | | | | | | | | |
| 9. PROJECT NO. | 11. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) | | | | | | | | | | | | | | | | | | | | |
| ⑮ ⑫ 87 P. | ⑬ CHES/NAVFAC | | | | | | | | | | | | | | | | | | | | |
| 10. DISTRIBUTION STATEMENT | | | | | | | | | | | | | | | | | | | | | |
| Distribution of this document is unlimited ⑭ FPO-1-77(20-VBL-4) | | | | | | | | | | | | | | | | | | | | | |
| 11. SUPPLEMENTARY NOTES | | 12. SPONSORING MILITARY ACTIVITY | | | | | | | | | | | | | | | | | | | |
| Work Breakdown Structure chart is found in Volume 1. | | Naval Facilities Engineering Command, Ocean Facilities Program, Criteria and Methods Program | | | | | | | | | | | | | | | | | | | |
| 13. ABSTRACT | | | | | | | | | | | | | | | | | | | | | |
| The report describes, defines, and interrelates the elements of suspended cable structure types of Fixed Ocean Facilities. The various elements are identified and defined by means of a generic breakdown structure that serves to categorize and completely define the tasks associated with this type of fixed ocean facility. | | | | | | | | | | | | | | | | | | | | | |
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| KEY WORDS | LINK A | | LINK B | | LINK C | |
|--|--------|----|--------|----|--------|----|
| | ROLE | WT | ROLE | WT | ROLE | WT |
| Ocean Facilities Engineering; Fixed Ocean Facilities; Cable Structures; Suspended Structures; Detailed Breakdown Structure; Description; Interfaces; | | | | | | |

FOREWORD

This report was prepared under Contract No. N62477-73-C-0359, Modification P00008, by the Lockheed Missiles & Space Company, Inc., Sunnyvale, California.

The report describes, defines, and interrelates the elements of suspended cable structure types of Fixed Ocean Facilities. The various elements are identified and defined by means of a generic breakdown structure that serves to categorize and completely define the tasks associated with this type of fixed ocean facility.

This report was prepared for the Department of the Navy, Chesapeake Division, Naval Facilities Engineering Command, Washington, D. C. Key personnel involved in its preparation were T. J. Anderson, R. Norton, and W. F. Hill, all of LMSC. Acknowledgment is also made for the specialized contributions from numerous personnel within the Ocean Systems organization of LMSC's Research and Development Division.

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INTRODUCTION

This report documents a detailed breakdown structure of Fixed Ocean Facility (FOF) components related to Suspended Cable (SC) Structures. The data presented herein describes, defines, and interrelates the elements of suspended cable structure types of FOF.

SCOPE

The data presented herein are restricted to suspended cable structures for application to sensor arrays, submarine cables, cable landings, and unmanned deep sea ship moorings – in effect, defining the type of SC hardware that is available and may be employed to construct a facility broadly defined by one of the four types of structure to which this report is addressed.

CONTENT AND ORGANIZATION

This report contains a numerical listing of the Breakdown Structure that lists the number and title of each component and subcomponent, a presentation of the Breakdown Structure units with supporting narrative in numerical order, and a bibliography of source documents. Terms that may be considered unusual are defined within the text as they occur. The FOF-SC Breakdown Structure is inserted in an envelope preceding the inside back cover, and may be removed and referred to while reading the report.

Figures 1 and 2 are included in this section to depict several typical facilities encompassed by the scope of this program. Figure 1 illustrates a typical mooring and three typical sensor arrays on the left, including vertical string with surface buoy, vertical string with submerged buoy, and horizontal string arrays. Figure 2 represents a sensor system from an acoustic array test installation. It is a fixed ocean facility type S2/E1, a subsurface structure combined with a bottom moored emplacement system and has a connected system.

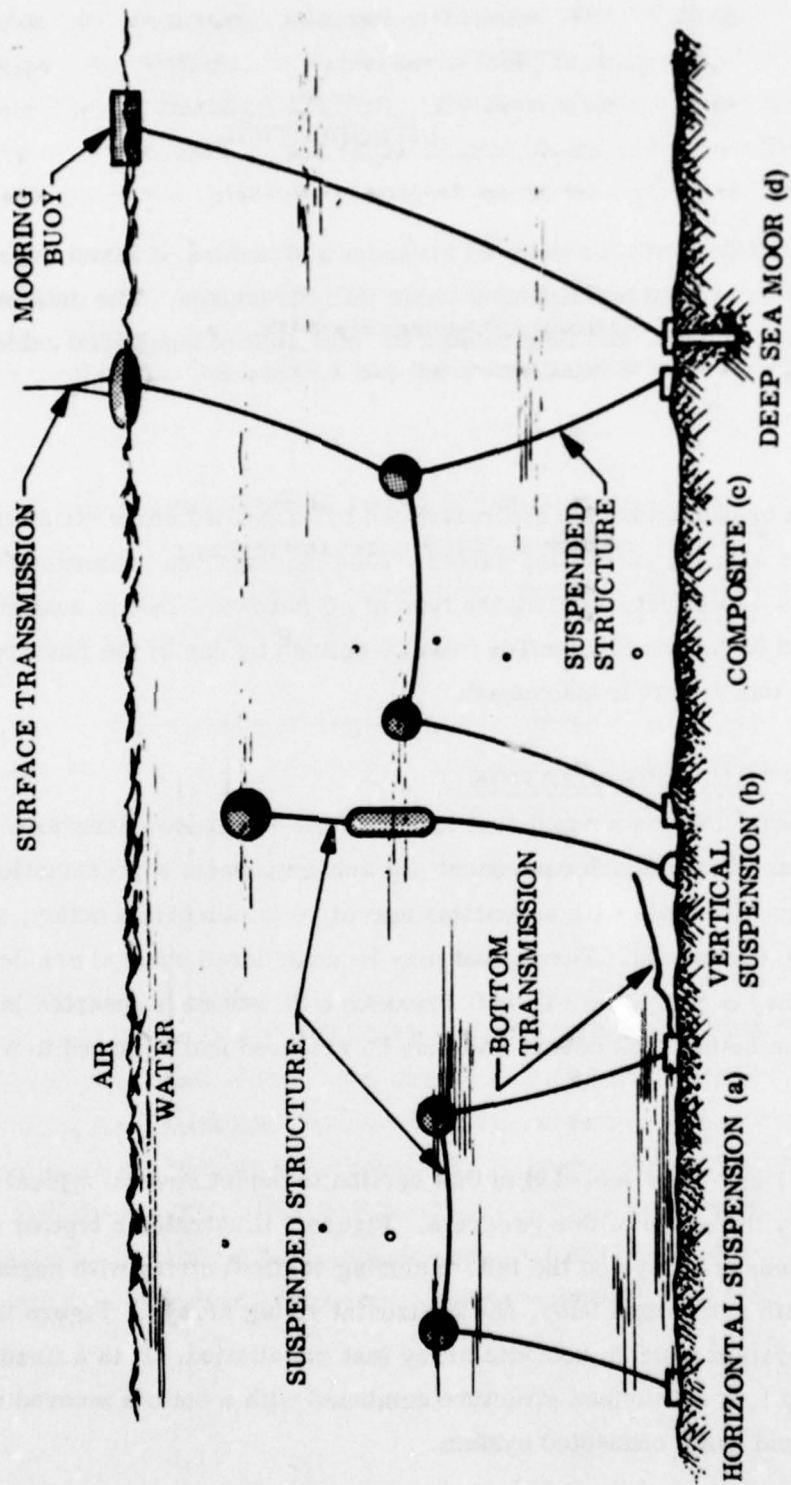


Fig. 1 Typical Mooring and Sensor Arrays

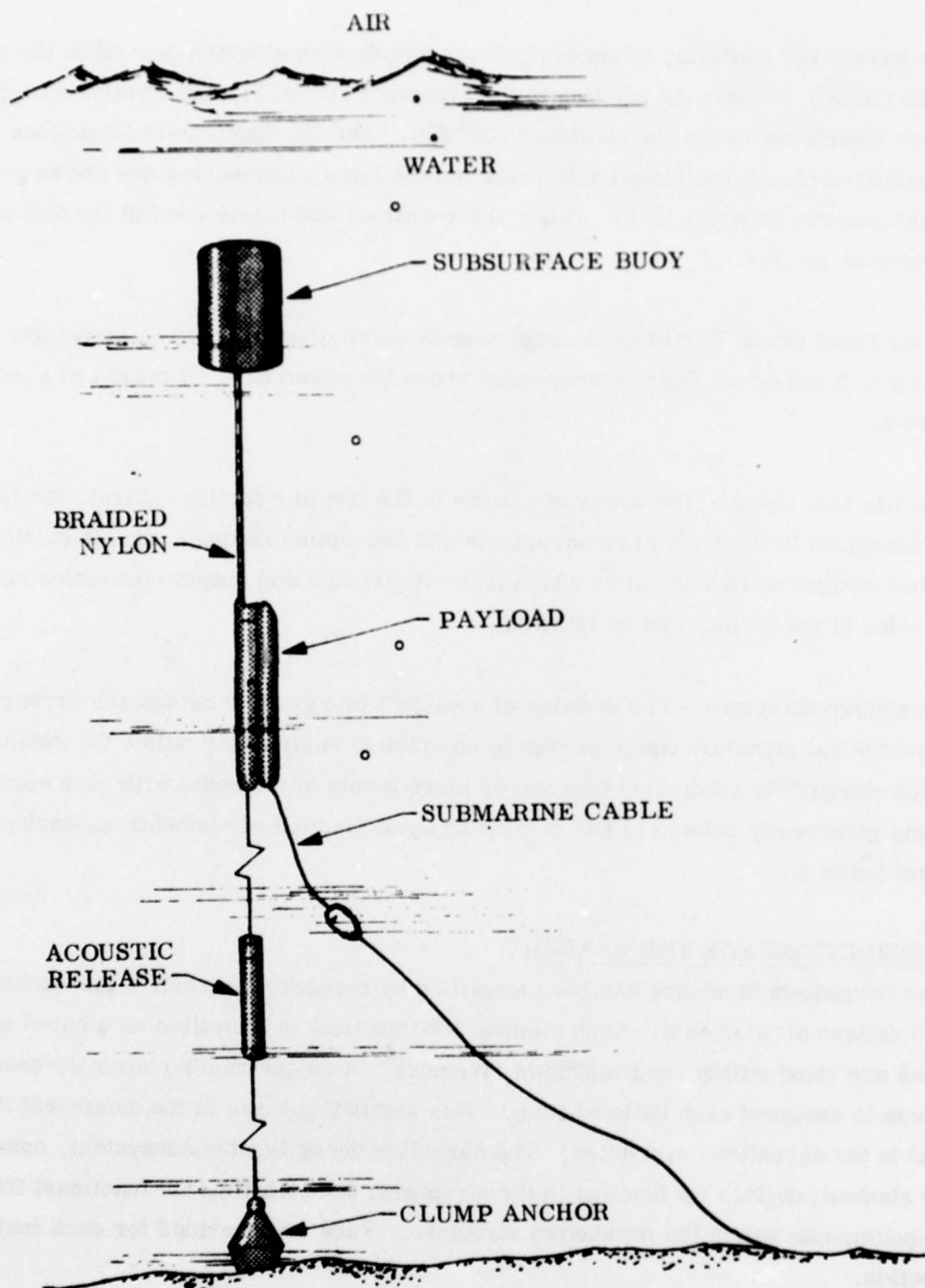


Fig. 2 Acoustic Array Test Installation

The narratives conform, in general, to a common format which describes the hardware (DESC), defines its function in the structure (FUNCT), and identifies its functional interfaces within the structure (INTER). The descriptions and functions are provided at the lowest identifiable level and the interrelationships are shown generally at the generic grouping level. Other abbreviations and terms used in the text are defined as follows:

Naval Fixed Ocean Facility - An underwater installation mounted on structures erected on the ocean floor or suspended above the ocean floor by means of a mooring system.

Facility Life Cycle - The order of actions in the life of a facility: First, the facility is conceived in the form of requirements and conceptual designs, then it is defined in detail designs and plans, after which it is constructed and put into operation and the mission of the facility can be fulfilled.

Breakdown Structure - The division of a subject into generic categories arranged in a hierarchical structure which serves to completely analyze and define the subject. Each category is subdivided into one or more levels of elements with each element being generically related to and defined by the collection of elements appearing at the level below it.

INSTRUCTIONS FOR THE READER

The Breakdown Structure has been amplified by supporting narrative that identifies and defines SC elements. Each element (SC function) is identified as a bullet under each unit (box) within the Breakdown Structure. A unique number for reference purposes is assigned each bulleted item. This number appears in the numerical listing and in the narrative description. The narrative describes the subsystem, component, or element; defines its function in the structure; and identifies its functional interface requirements within the breakdown structure. Tabs are provided for each major section.

SC-000 SUSPENDED CABLE STRUCTURES

DESC - For the suspended cable structures discussed in this report, the payload (mission equipment) is attached to flexible structural members which are anchored to the bottom and suspended from a buoyant element, or alternatively, as with submarine cables, the system lies on the sea floor.

The required location of a FOF may be specified with varying degrees of precision. The number and type of sensors, their relative locations in space, the orientation of the array, the ambient current profile, and the depth of water are other parameters that will affect the general configuration of a sensor array, as well as the detail design of the subsystem and components. For a deep sea ship mooring, the location, the depth of water, the current profile, and the type of ship to be moored are the most important considerations.

In addition to the basic components, the Suspended Cable Structure facility will have components related to logistics, operations installation requirements, and, in some cases, shore facility requirements.

- Logistic Support System - This system may include maintenance subsystems as necessary to transport personnel and equipment to the facility to perform routine maintenance or repairs. Although the facility is not manned, boarding for maintenance or recovery may be necessary and therefore it must have equipment to allow boarding of personnel from transport vehicles. Small facilities may be lifted from the water for maintenance on a ship, whereas large ones may be towed to a maintenance/repair site. All equipment on the facility must be compatible with the maintenance equipment and procedures used.

The logistic system may also include a replenishment subsystem to periodically resupply fuel or other consumables on the facility. Suitable fittings must be provided on the facility to interface with the replenishment equipment.

- Operational System - The services performed by the facility must be compatible with the user's equipment and procedures. If data are collected in the facility, the retrieval equipment or the facility must be compatible with equipment and ships planned for in retrieving instruments or records from the facility.
- Installation System - The overall design of the facility must be compatible with the equipment and facilities used for transportation to the site, emplacement at the designated location, and in some cases, recovery. Additionally, the specified accuracy for emplacing the facility, with reference to geographic coordinates, orientation, and depth below the surface, will have an influence on the design of facility features as well as on the equipment and techniques used for emplacing it.
- Shore Facilities - Interfaces between the ocean facility and a shore facility occur when the two are linked by systems that transmit data or power. The routing of submarine cables and the terminal equipment at either end may have a strong influence on the selection of the facility location.

The first level breakdown structure for a Suspended Cable Structure is shown in Fig. SC-000-1.

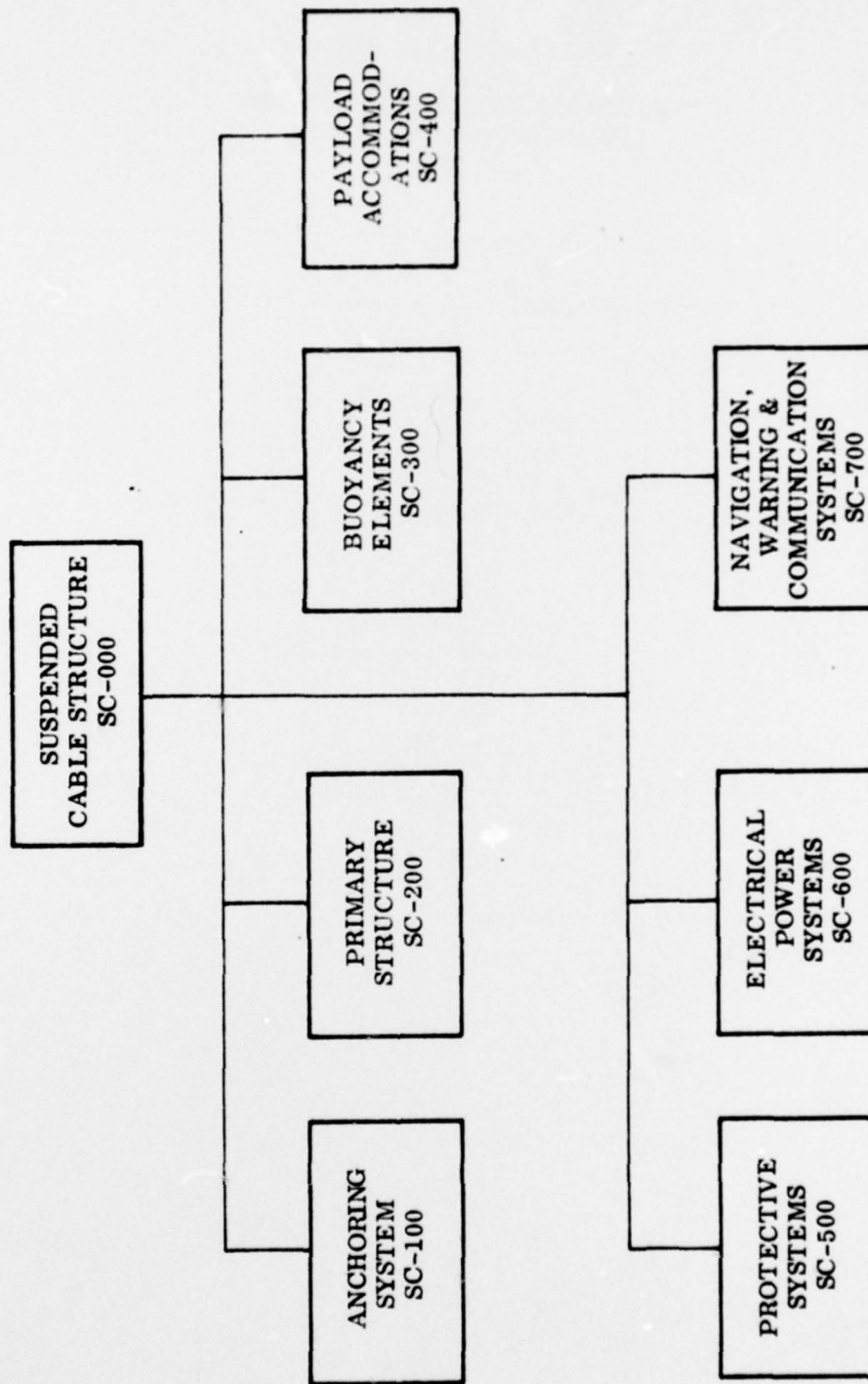


Fig. SC-000-1 Suspended Cable Structure - First Level Breakdown Structure

NUMERICAL LISTING
OF
SUSPENDED CABLE STRUCTURES
BREAKDOWN STRUCTURE
(SC-100)

| SC | ELEMENT | |
|-----|----------------------------|--------------------------------------|
| 000 | SUSPENDED CABLE STRUCTURES | |
| | 100 | ANCHORING SYSTEM |
| | 110 | ANCHOR TYPES |
| | 111 | DEADWEIGHT/MASS |
| | 112 | DRAG |
| | | 112.1 Stockless |
| | | 112.2 Eells |
| | | 112.3 Danforth |
| | | 112.4 Lightweight (LWT) |
| | | 112.5 STATO |
| | | 112.6 Mushroom |
| | 113 | EMBEDMENT |
| | | 113.1 Gravity-Driven Clump |
| | | 113.2 Propellant-Activated Embedment |
| | | 113.3 Hydrostatic |
| | | 113.4 Vibratory |
| | 114 | PILE |
| | | 114.1 Drilled/Cast-in-Place |
| | | 114.2 Driven |
| | | 114.3 Auger |
| | 115 | OTHER TYPES |
| | | 115.1 Combination |
| | | 115.2 Rockbolts |
| | 120 | ANCILLARY HARDWARE |
| | | 120.1 Crown Lines |
| | | 120.2 Swivels/Shackles |
| | | 120.3 Release Devices |

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NUMERICAL LISTING
OF
SUSPENDED CABLE STRUCTURES
BREAKDOWN STRUCTURE
(SC-200)

| SC | ELEMENT | |
|--------|----------------------------|--|
| 000 | SUSPENDED CABLE STRUCTURES | |
| 200 | PRIMARY STRUCTURE | |
| 210 | CABLES | |
| 210.1 | Wire Rope | |
| 210.2 | Synthetic Rope | |
| 210.3 | Glass Filament | |
| 210.4 | Electromechanical | |
| 220 | STRUTS | |
| 220.1 | Tension Members | |
| 220.2 | Compression Members | |
| 230 | CHAIN | |
| 230.1 | Die-Lock Link | |
| 230.2 | Stud Link | |
| 230.3 | Welded Link | |
| 230.4 | Cast Square Link | |
| 230.5 | Open Link | |
| 230.6 | Rod Link | |
| 240 | RIGGING AND FITTINGS | |
| 240.1 | Link | |
| 240.2 | Shackle | |
| 240.3 | Ring | |
| 240.4 | Hook | |
| 240.5 | Clamp | |
| 240.6 | Fastener | |
| 240.7 | Swivel | |
| 240.8 | Thimble | |
| 240.9 | Turnbuckle | |
| 240.10 | Stopper | |
| 240.11 | Plate | |
| 240.12 | Padeye | |

NUMERICAL LISTING
OF
SUSPENDED CABLE STRUCTURES
BREAKDOWN STRUCTURE
(SC-300)

| SC | ELEMENT | | |
|-----|----------------------------|-------------------|----------------------|
| 000 | SUSPENDED CABLE STRUCTURES | | |
| | 300 | BUOYANCY ELEMENTS | |
| | | 310 | SURFACE FLOATS |
| | | 310.1 | Hollow |
| | | 310.2 | Solid |
| | | 320 | SUBSURFACE FLOATS |
| | | 320.1 | Pressure Vessels |
| | | 320.2 | Syntactic Foam |
| | | 320.3 | Pressure Compensated |

NUMERICAL LISTING
OF
SUSPENDED CABLE STRUCTURES
BREAKDOWN STRUCTURE
(SC-400)

| SC | ELEMENT | |
|-----|----------------------------|--|
| 000 | SUSPENDED CABLE STRUCTURES | |
| | 400 | PAYLOAD ACCOMMODATIONS |
| | 410 | SEA SURFACE ENCLOSURES |
| | 420 | SUBSEA ENCLOSURES |
| | | 420.1 Pressure-Compensated, Oil-filled |
| | | 420.2 Dry Housings |
| | | 420.3 Penetrators and Access |
| | 430 | ATTACHMENT PLATES AND FITTINGS |

NUMERICAL LISTING
OF
SUSPENDED CABLE STRUCTURES
BREAKDOWN STRUCTURE
(SC-500)

| SC | ELEMENT | |
|-----|----------------------------|--------------------------|
| 000 | SUSPENDED CABLE STRUCTURES | |
| | 500 | PROTECTIVE SYSTEMS |
| | 510 | MECHANICAL (FENDERS) |
| | | 510.1 Pneumatic Fenders |
| | | 510.2 Rope Fenders |
| | | 510.3 Rubber Fenders |
| | | 510.4 Standoff Boom |
| | 520 | COATINGS |
| | | 520.1 Paints and Tars |
| | | 520.2 Cable Jacketing |
| | | 520.3 Antifouling Paints |
| | 530 | CATHODIC PROTECTION |
| | | 530.1 Sacrificial Anodes |
| | | 530.2 Impressed Current |

NUMERICAL LISTING
OF
SUSPENDED CABLE STRUCTURES
BREAKDOWN STRUCTURE
(SC-600)

| SC | ELEMENT | |
|-----|----------------------------|------------------------------|
| 000 | SUSPENDED CABLE STRUCTURES | |
| | 600 | ELECTRICAL POWER SYSTEMS |
| | 610 | POWER SOURCES |
| | | 610.1 Battery |
| | | 610.2 Fuel Cell |
| | | 610.3 Nuclear |
| | | 610.4 Thermoelectric |
| | | 610.5 Shore Power |
| | 620 | CONTROLS |
| | | 620.1 Fuses |
| | | 620.2 Circuit Breakers |
| | | 620.3 Regulators |
| | | 620.4 Switching Gear |
| | | 620.5 Rectifiers |
| | | 620.6 Converters |
| | | 620.7 Inverters |
| | | 620.8 Transformers |
| | 630 | POWER DISTRIBUTION SYSTEMS |
| | | 630.1 Electrical Cables |
| | | 630.2 Junction Boxes |
| | | 630.3 Connectors |
| | | 630.4 Electrical Penetrators |
| | | 630.5 Slip-Rings |

NUMERICAL LISTING
OF
SUSPENDED CABLE STRUCTURES
BREAKDOWN STRUCTURE
(SC-700)

| SC | ELEMENT | |
|-----|----------------------------|--|
| 000 | SUSPENDED CABLE STRUCTURES | |
| | 700 | NAVIGATION, WARNING, AND COMMUNICATION SYSTEMS |
| | 710 | ACOUSTIC |
| | | 710.1 Bells, Horns, and Whistles |
| | | 710.2 Transponders |
| | | 710.3 Pingers |
| | | 710.4 Reflectors |
| | 720 | VISUAL |
| | | 720.1 Lights |
| | | 720.2 Reflectors |
| | | 720.3 Marker Buoys |
| | 730 | ELECTROMAGNETIC |
| | | 730.1 Telecommunications |
| | | 730.2 Signal Conditioners |
| | | 730.3 Radar Reflectors |

SC-100 ANCHORING SYSTEM

DESC - An anchoring system comprises all of the hardware, excluding the cable, that anchors a cable system. Included are the anchor(s), attachment and release devices, crown line, and swivels (see Fig. SC-100-1).

The effectiveness of an anchoring system may be increased by the utilization of more than one anchor of the same type or, alternatively, of different types in combination.

FUNCT - Anchoring systems are employed to provide a positive location for Suspended Cable Structures, and in some cases fulfill a secondary purpose of providing the reaction to net buoyancy forces.

INTER - Anchor systems interact with the attaching cable systems and with the sea bed.

SC-110 ANCHOR TYPES

DESC - An anchor is a device that rests on or penetrates the ocean floor and is designed to resist the pull of mooring lines or other lines attached to it. Anchors of many types have been devised to satisfy varying combinations of pulling force vector and seafloor properties. In addition, the type of anchor used may depend on the capabilities of the equipment available for anchoring and for recovery, the life expectancy, cost, and other factors.

Among the types of anchors are the following: deadweight, drag, embedment, pile, and other types. Descriptions of these anchor types are provided in elements SC-111, SC-112, SC-113, SC-114, and SC-115 below.

FUNCT - The function of an anchor is to fix the end of a mooring line to the ocean bottom.

INTER - The design must provide for the interactions between the anchor structure and configuration, the soil/bottom properties and conditions, and the methods for location or placement of the anchor in the sea bottom. The load forces against which

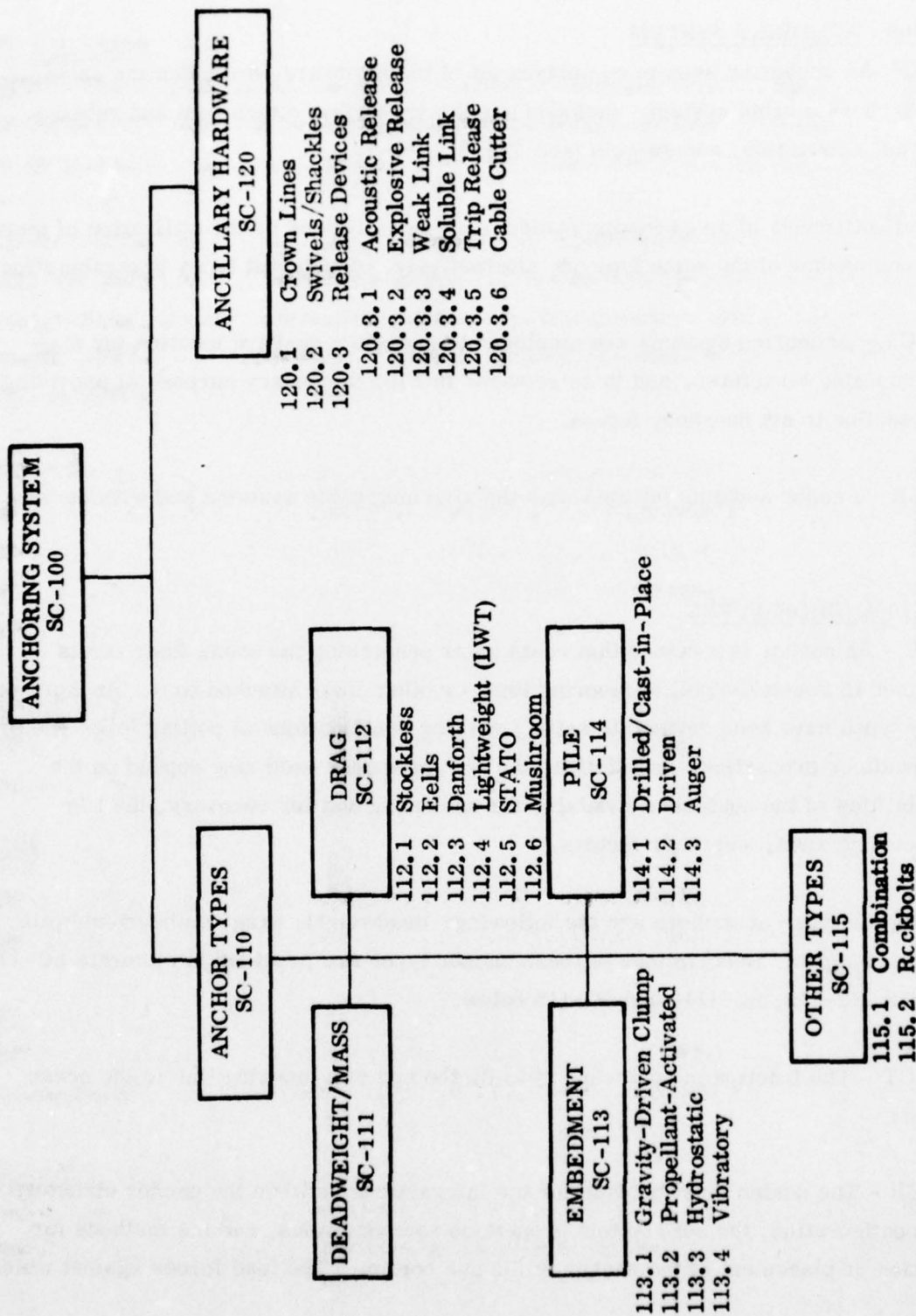


Fig. SC-100-1 Anchoring System - Breakdown Structure

the anchor must react are the static and dynamic forces of the buoyant element, bottom current conditions, and in some cases loads caused by tsunami waves, earth movement, and explosion. The consideration of dynamic loads must include (where applicable) surface wave induced buoyant element motions, force vector direction changes from both surface and submerged buoyant element movements (from changes in current direction), and loads induced by cable strumming. In addition, the anchor design must consider the requirements for both short-term holding, long-term holding (creep), and recovery. The anchor design must make provisions for proper attachment to the mooring line. In cases where the mooring line serves also as an electrical transmission line, provisions must be made at the anchor for connection or transition from mooring line conductors to a submarine cable.

The anchor must be compatible with equipment to be used for placing it on the bottom and, where required, for recovering it. This includes the equipment on the surface ship used for emplacement such as winches, cranes, releases, etc., as well as components that may be attached to the anchor such as lines for lowering or lifting, releases, and grapnel lines.

SC-111 DEADWEIGHT/MASS

DESC - Deadweight anchors (also known as clump or sinker anchors) consist of simple weights resting on the bottom. Their resistance to vertical forces is their weight. Their resistance to lateral forces is derived from friction on the bottom, although some additional resistance will be provided by minor penetration in soft bottom materials. Deadweight anchors are the least efficient anchors in terms of holding power per pound of anchor. They are inexpensive to produce, the materials commonly used being concrete and steel. However, the size and weight necessary to make them effective cause considerable handling difficulties during emplacement. This increases both the cost and the risk of emplacement operations.

FUNCT - A deadweight anchor is used where recovery is not important, or at least infrequent, and where low manufacturing cost is a prime consideration. Because of their weight they can be used only where facilities for handling them can be made available.

SC-112 DRAG

DESC - The drag anchor is the conventional type, designed so that when dragged along the bottom it "bites" into and buries itself in the bottom material. The shearing resistance of the bottom material therefore increases the horizontal holding power of drag anchors to many times their weight, depending on the bottom material and on the anchor configuration. If the anchor line pull has a sufficiently large vertical component, the anchor may be pulled out of the soil, and have to be reset by dragging. Many configurations of drag anchors are used such as the stockless, Eells, Danforth, lightweight, STATO, and mushroom. These are briefly described below and illustrated in Fig. SC-100-2.

FUNCT - The basic drag anchor function is as defined in SC-110. It is used where the anchor is intended to be recovered and where some drag can be tolerated before the anchor is set and is most suitably used where the pull-off is at a small angle to the bottom or is parallel to the bottom. It may also be used to supply the drag component in a combination deadweight/drag anchor (see SC-115).

SC-112.1 Stockless

DESC - The stockless anchor is the standard Fleet ship mooring and, depending on soil conditions, may drag relatively far before setting.

SC-112.2 Eells

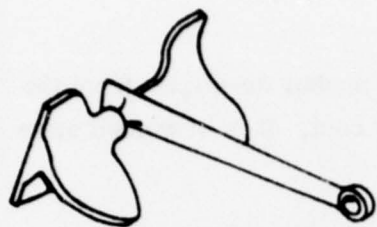
DESC - The Eells anchor is a proprietary design much used in salvage operations. A special fluke configuration gives some suction to increase holding power.

SC-112.3 Danforth

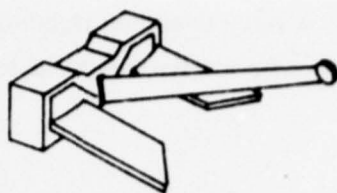
DESC - The Danforth anchor is a lightweight unit of proprietary design having good holding characteristics for its weight. Stock and flukes are integral.

SC-112.4 Lightweight (LWT)

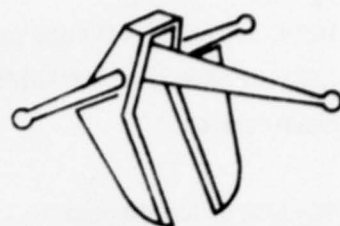
DESC - The lightweight anchor is similar in principle to the Danforth in having a stock and flukes and is relatively light compared to the stockless.



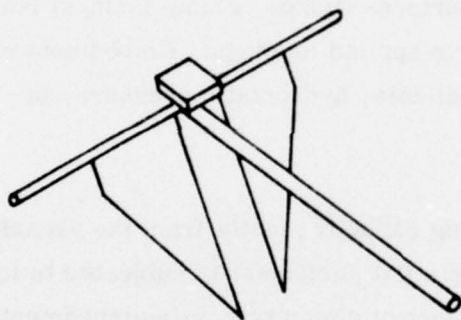
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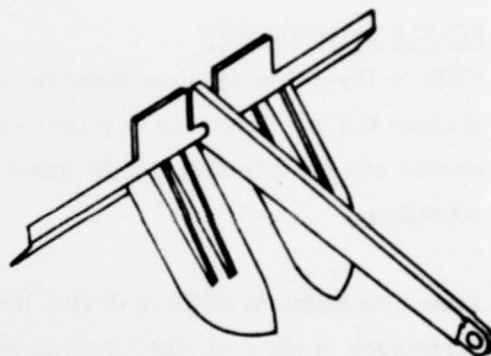
Eells



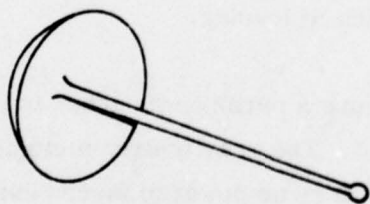
Lightweight



Danforth



STATO



Mushroom

Fig. SC-100-2 Drag Anchors

SC-112.5 STATO

DESC - The STATO anchor is a Navy designed lightweight anchor developed from the LWT to have greater holding power for its weight at lower cost. It is of welded plate construction.

SC-112.6 Mushroom

DESC - The mushroom anchor has, in effect, one circular fluke which gives less holding power for its weight since it does not bury as readily. However, it has no specific "flukes down" position for holding. It combines some of the characteristics of the deadweight and drag anchors.

SC-113 EMBEDMENT

DESC - Direct embedment anchors use flat surfaces (flukes, clump facings) buried beneath the sea bottom to develop resistance to applied loadings. Embedment of the anchor can be accomplished by gravity, propellants, hydrostatic pressure, or vibration.

Direct embedment anchors derive their holding capacity mostly from the shearing resistance of the soil mobilized as the anchor's flat surface(s) is subjected to load. In addition to the shearing resistance, the weight of clump type self-embedment anchors contributes to the holding capacity. Unlike conventional drag anchors, which tend to embed deeper as loading is increased but continue to resist the load, embedment anchors pull out of the soil at their ultimate capacity, which is dependent upon anchor size, soil type, type of loading, and duration of loading.

FUNCT - Embedment anchors are used where a permanent anchor is desirable or permissible since they cannot be recovered. The gravity driven clump is a simple reliable design suitable for soft bottoms. Since no powered mechanism or explosive is involved, the possibility of sonic detection is minimized.

The propellant-actuated embedment anchor is most suitable for hard or rock bottoms. The hydrostatic type is similar in application but will not penetrate as hard a bottom structure and requires no external power source.

The vibratory embedment anchor may be used in soft soil or sand and has a limited holding power since, to date, size has been a limitation. 6,000 feet is the maximum depth to which this type has so far been used.

SC-113.1 Gravity-Driven Clump

DESC - Gravity-driven clump anchors consist of an axisymmetric mass of sufficient size and shape to drive itself into ocean bottom sedimentary soils to depths sufficient to develop required holding capacity. Surfaces are usually hemispherical. Weight of clump anchor may contribute appreciably (50% or more) to holding capacity.

SC-113.2 Propellant-Actuated

DESC - Propellant-actuated embedment anchors depend upon the fluke areas and depth of penetration for holding capacity. The anchor is driven into the soil by a solid propellant charge. While penetrating soils during emplacement, the flukes are folded, but after penetration a slight pull on the anchor causes the flukes to extend into a resistive position. For penetration into rock, the flukes are rigid and retention is due to penetration only.

SC-113.3 Hydrostatic

DESC - Hydrostatically driven anchors are similar to propellant-actuated embedment anchors in configuration and mechanics of resistance to pullout. Instead of a propellant fired for propulsion, an air cavity implodes due to excess hydrostatic pressure at the design depth causing a ram to drive the anchor flukes and shaft into the soil.

SC-113.4 Vibratory

DESC - Vibratory-driven embedment anchors derive their holding capacity from a circular plate fluke keyed into position at design penetration. A hydraulically actuated vibrator attached to the upper end of the shank of the anchor provides the "hammering" effect for driving. Upon reaching design penetration depth, the actuator is reversed and releases itself from the shank for retrieval. Similar to vibratory-driven piles, this type of anchor is more effective in cohesionless soils (silts, sands).

SC-114 PILE

DESC - Pile anchors are structural members of timber, concrete, and/or steel that penetrate the ocean floor and transmit loads to lower level soil masses. Unlike structural foundation piles, the primary load direction on anchor piles is vertically upward. Anchor piles resist upward and lateral loads by friction and lateral bearing capacity. Placement of anchor piles can be accomplished by driving, drilling, jetting, screwing, or by placement in a hole filled with concrete.

FUNCT - Pile-type anchors are limited in the depth at which they can be emplaced by the characteristics of the driving equipment. For comparable depth of drive, the mechanically driven pile has better holding power than the pile driven by jetting. The screw pile is particularly applicable where there is a large uplift load and may be used in any except a rock bottom.

INTER - See Anchor Types (SC-110).

SC-114.1 Drilled/Cast-in-Place

DESC - Drilled and cast-in-place anchor piles are usually cylindrical in shape and made of concrete. Precast concrete pile anchors can be placed in drilled or jetted holes and grouted in place or may be driven directly into the soil. Cast-in-place anchor piles can be poured directly into emplaced casings of steel.

SC-114.2 Driven

DESC - Driven anchor piles are usually made of steel rolled sections driven directly into load-bearing stratum. Open steel sections (pipe) may also be driven directly. Driving of the pile can be accomplished by hammer (pile driver) or by vibration.

SC-114.3 Auger

DESC - The rotating screw penetrates most soils with little difficulty. Screw-diameter-to-shaft-diameters ratios are usually 2:1. Jetting can be accomplished if the shaft is hollow. The large uplift resistance is created by the pull of the screw flanges against the weight of an inverted cone of soil.

SC-115 OTHER TYPES

DESC - Two other types of anchor not in any of the previous categories are rockbolts and combination anchors. These are further described below.

SC-115.1 Combination

DESC - By combining two types of anchors, the holding power of the components may be optimized. Thus the holding power of a drag anchor against vertical pull may be optimized by adding a clump on the line in order to reduce the lift and thus the possibility of breakout of the drag anchor.

FUNCT - Combination anchors may be used where the vertical and horizontal loads on the anchor are of comparable magnitude.

SC-115.2 Rockbolts

DESC - Rockbolts are bolts with liners designed to expand and grip when inserted and torqued in a hole predrilled in rock or masonry.

FUNCT - Rockbolts attach structures to rock or concrete where loads applied are moderate.

INTER - See Anchor Types (SC-110).

SC-120 ANCILLARY HARDWARE

DESC - In addition to anchors, the anchoring system includes various other items which are used in the placing of the anchor and in attaching the anchor to the mooring line or releasing it from the mooring. This ancillary hardware includes such items as crown lines, to aid in anchor placement and retrieval; swivels and shackles, for connecting elements of the anchoring system; and various release devices, for disengaging crown lines or mooring lines from the anchor.

SC-120.1 Crown Lines

DESC - Crown lines are lines extending from a surface buoy to an anchor.

FUNCT - A crown line may be used either alone or in conjunction with the mooring line to assist in emplacement of an anchor where accurate placement is required. It may also be used for the retrieval of temporary sinkers or other gear used during installation operations.

INTER - Swivels or Shackles, etc. (SC-120.2) are used to connect the crown line to the surface buoy (SC-310) or other gear and to the anchor or Release Device (SC-120.3).

SC-120.2 Swivels/Shackles

DESC - A swivel is a mechanical connection that can be installed between two lengths of line or between a line and other equipment to permit axial rotation of one end of the connection relative to the other. A shackle is a U-shaped link having a detachable pin across the open end of the U. It may be installed wherever connection is made between two eyes, e.g., at the ends of cables or at padeyes.

FUNCT - Typically, the swivel is used to prevent hockling of a line by relieving rotation in the line caused by changing axial load or by rotation of the complete line. A shackle is used to connect together two cables or chains or to connect the chain or cable to a padeye on a structure or anchor.

SC-120.3 Release Devices

DESC - A release device may be any one of a number of mechanical connections in a mooring or other line which, upon command or after a predetermined time, can be caused to disconnect.

SC-120.3.1 Acoustic Release

DESC - An acoustic release is a mechanical connector that can be remotely disconnected by transmitting an acoustic signal from a surface ship mounted transmitter. The release has its own power supply and the signal is usually coded to preclude response to a spurious signal.

SC-120.3.2 Explosive Release

DESC - An explosive release achieves disconnection by shearing a link with a pyrotechnic charge. The mechanism may be activated remotely using the same technique described in SC-120.3.1.

SC-120.3.3 Weak Link

DESC - A weak link disconnect may be a shear pin calculated to fail at a known load.

SC-120.3.4 Soluble Link

DESC - A soluble link consists of a water soluble compound that is used as an adhesive or retainer in potting-in-place applications. When immersed in water, the soluble link will effect release. While the minimum time is predictable, the actual time to release may not be accurate. A variation of the soluble link is the corrodible link made of metal which corrodes rapidly relative to the rest of the structure.

SC-120.3.5 Trip Release

DESC - A trip weight release is a mechanical device actuated by sliding a weight down the mooring or crown line from the surface.

SC-120.3.6 Cable Cutter

DESC - A cable cutting device consists of a blade, anvil, and a power source that are attached to cables at desired locations and that sever a cable by impulse cutting action. They are generally explosively powered where fast impulse cutting action is required. Some use hydraulic power for cutting where speed is not essential and the material to be cut may be resilient or energy absorbent.

FUNCT - Examples of uses are (1) to release a crown line after it has been used to assist in emplacing an anchor and (2) to release a mooring line from its anchor where it is necessary to recover a submerged cable structure.

SC-200 PRIMARY STRUCTURE

DESC - In a suspended cable system the primary structure is comprised of those elements that support and connect a payload to an anchoring system. The four categories of equipment within SC-200 are cables, struts, chain, and rigging and fittings (see Fig. SC-200-1).

FUNCT - The primary structure strength members of the suspended cable structure include mooring and suspension lines. They connect and transmit loads between other elements of the SC structure such as buoys and anchors. In addition, strength members provide support for auxiliary components mounted on the SC structure such as sensors and equipment. In the cable and line configurations, they function as strength members of integrated electromechanical cables.

INTER - Provisions are required for the mechanical connection of the flexible strength members to each other and to other elements on the SC structure such as buoys, anchors, sensors, and equipment. Where they are used in electromechanical cable configurations, provision is also required for electrical connection and continuity across the mechanical joints. Strength member end fittings and mechanical connectors are discussed in SC-240 and interface with Anchoring System (SC-100), Buoyancy Elements (SC-300), Payload Accommodations (SC-400) and other elements of the primary structure such as Struts (SC-220), Chain (SC-230), and Release Devices (SC-120.3).

SC-210 CABLES

DESC - Cables are flexible strength members which can sustain tension loads only. They are manufactured from a variety of materials and in various constructions. The choice of an actual strength member depends upon the required performance, loading, installation techniques and equipments, environment, life, reliability, and vulnerability to biochemical attack. Because of their flexibility, they lend themselves to compact stowage on drums, in chain and rope lockers, and tanks, or by faking on deck.

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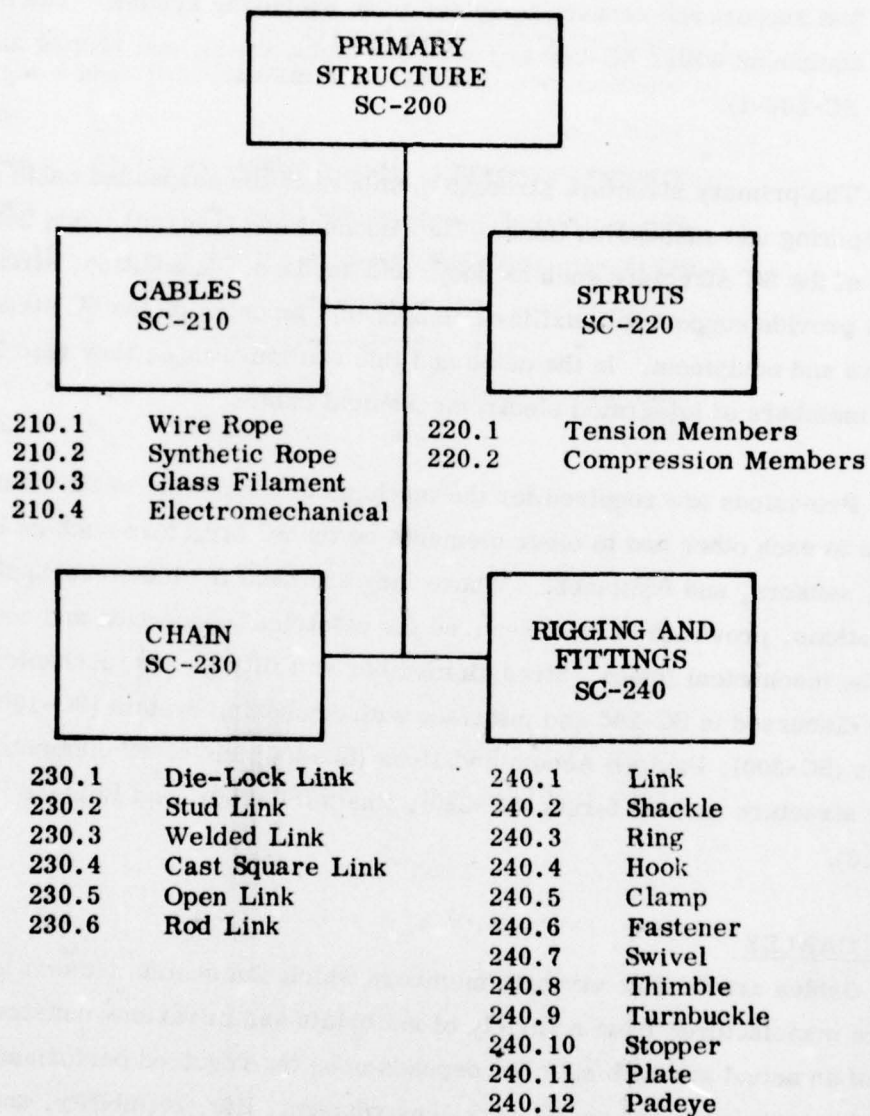


Fig. SC-200-1 Primary Structure - Breakdown Structure

Cables are classified by their material and construction in the narratives that follow. Properties and characteristics of synthetic rope are summarized in Table SC-200-1 and of wire rope in Ref. 1.

Table SC-200-1
CABLE TYPES (SYNTHETIC ROPE)

| Material | Relative Strength | Specific Gravity | Characteristics |
|-------------------|---------------------------|------------------|---|
| Nylon | Strongest, Used as ref | 1.14 | Shock resistant Permanent elongation under heavy load Rotproof, mildewproof |
| Polyester | 77% | 1.38 | Good wet strength Rotproof, mildewproof Lower elongation than nylon and more acid resistant |
| Polypropylene | 60% | 0.91 | Buoyant in water Rotproof, mildewproof Lower elongation than nylon |
| Polyethylene | 50% | 0.95 | Slightly buoyant in water Rotproof, mildewproof Wet strength equals dry strength |
| Glass filament | | 2.5 | Resists marine environment Brittleness - low fatigue life Requires large bend radii |
| Construction | | | |
| Twisted | | | Will revolve axially under load |
| Plaited/braided | | | Torque balanced |
| Parallel filament | | | Torque balanced, low elongation/high strength |

SC-210.1 Wire Rope

DESC - The construction and uses of wire rope are described fully in Ref. 1.

FUNCT - Wire rope is used as primary structure in suspended cable structures where strength, low elongation, resistance to fishbite, and abrasion resistance is required. Preformed torque-balanced rope is generally used where it is important to avoid hockling and/or excessive rotation, e.g., a free end at an anchor or float mooring. Prestressed wire rope is used where dimensional stability and minimum elongation under load is critical. Multi-wire, fiber core wire rope is generally used for greater flexibility in stowage, handling and installation. Galvanized, aluminized, or plastic jacketed coatings provide additional resistance to corrosion. Plastic jackets also afford additional abrasion resistance. Wire rope can be used as the strength member of integrated electromechanical cables.

SC-210.2 Synthetic Rope

DESC - Synthetic ropes are available in several materials and constructions. The materials and their characteristics are described in Ref. 1. Synthetic ropes are constructed in a variety of ways:

Twisted - similar in construction and behavior to wire rope

Plaited and Braided - a torque balanced construction

Parallel Filament - highest strength with lowest elongation

FUNCT - Nylon and dacron are commonly used for primary structure for suspended cable structures. They provide moderate strength, light weight, flexibility, ease of handling, and excellent resistance to the marine environment. Nylon's high elongation makes it suitable for shock load applications and it is used extensively for anchoring surface buoys with slack or taut moors. Parallel filament polyester fiber rope offers the highest stiffness of the common synthetics and is used where limited elongation under load is required. Because of relatively high elasticity, the common synthetic fiber ropes are not generally suitable as strength members of electromechanical cables.

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1. Department of the Navy, Bureau of Yards and Docks, Design Manual, Harbor and Coastal Facilities, NAVDOCKS DM-26, 1962.

Plaited, braided, or parallel filament construction should be used where hocking or excessive rotation are undesirable, as at an anchor or float mooring. None of the synthetics are immune to fishbite attack without special protection features.

SC-210.3 Glass Filament

DESC - Glass filament cables are similar in construction to other synthetics but with fiberglass used as the material. This has high strength, low elongation, low weight, and excellent resistance to deterioration in sea water. Because the fibers are brittle, large bend radii are necessary. Fatigue life is low due to broken fibers abrading adjacent fibers.

SC-210.4 Electromechanical

DESC - Electromechanical (EM) cables consist of rope materials for mechanical load bearing and electrical wires for transmission of electrical power or signal. The load-bearing member consists of wire or fiber strands similar in construction to those described in SC-210.1, SC-210.2, and SC-210.3. The electrical members are cabled or layed in the EM cable with sufficient slack so that no loads are transmitted to the electrical members. The EM cables are generally categorized as follows:

- a) Internal Strength Member - Wire or fiber rope in center and electrical wires cabled or layed around the rope with an external protective or containment jacket.
- b) External Strength Member - Electrical members in a center core with first a protective jacket and then wire or fibers braided or layed around the electrical cable, which give mechanical strength and protection.
- c) Integral Strength Member - The electrical wires either layed or woven into the fiber strength members with a sufficient slack to prevent load transmittal to electrical members (generally in parallel or very long lay fiber cables).

- d) **Attached Strength Member** - The electrical members are separate from and attached in parallel to wire rope strength member either with clamps or an outer jacket. This configuration has handling problems during installation and high drag.

FUNCT - The EM cable has two functions: it conducts electrical power or signals and is a strength member to support its own weight or to provide primary (mooring or suspension line) or secondary (equipment or sensor suspension) mechanical load carrying capability. In addition, an EM cable may be laid on the bottom as a transmission line, in which case its load-bearing capabilities are necessary only during installation or retrieval.

INTER - The electrical components of the EM cable may interface with and are designed in conjunction with the requirements for Electrical Power Systems (SC-600), and with Navigation, Warning, and Communication Systems (SC-700).

SC-220 STRUTS

DESC - Struts are rigid elements or links, within a system possessing overall flexibility, that cause two or more members to remain at known respective locations.

FUNCT - Struts provide a rigid link in a system requiring dimensional stability or maintain buoyantly supported members at correct separation distances.

INTER - Struts are mechanically connected to the Primary Structure (SC-200), less frequently to the Anchoring System (SC-100) and to Buoyancy Elements (SC-300). Provision for attachment to elements of Electrical Power Systems (SC-600) and Navigation, Warning, and Communication Systems (SC-700) may also be required.

SC-220.1 Tension Members

DESC - Tension members are structural elements carrying only tension loads at those locations where it would be inappropriate to use a cable or chain. They are generally constructed from bars, rods, or rolled shapes and are welded, bolted, or pinned. The struts may be constructed in one piece or in several pieces assembled at sea, depending on size and installation provisions.

FUNCT - Tension members are relatively short for the load being carried where cable and cable terminals cannot readily be assembled to the required length. Tension struts may also be used where elongation (stretch) must be minimized to maintain the structural configuration.

SC-220.2 Compression Members

DESC - Compression members function as struts and carry compression loads primarily, but have the capability to carry tension loads. They may be used between two or more buoyancy elements or to maintain the structural geometry of a suspended cable structure. Large compression members, especially if horizontally oriented, may be provided with buoyancy to reduce dependency on buoyancy elements and to minimize the instability arising from the weight of the strut. Buoyancy may be obtained by making hollow members watertight or by the addition of buoyant material.

FUNCT - Depending on their length in relation to the required load-carrying capability, compression members may be constructed from rolled shapes, pipe, or fabricated frames or trusses. Where hollow sections are used, as for instance pipe, consideration must be given either to sealing it against sea water intrusion or to allowing flooding, or providing anticorrosion measures.

SC-230 CHAIN

DESC - Chains are flexible strength members composed of interlocking solid links. Steel chains are classified by the type of chain links which are described below (see Fig. SC-200-2).

These chain types and their uses are also described in detail in Ref. 1.

SC-230.1 Die-Lock Link

DESC - Die-lock links consist of two parts, a C-shaped half link having grooved tongs which are inserted into the legs of an A-shaped half link. After insertion, the A half is compressed into the grooves of the C half.

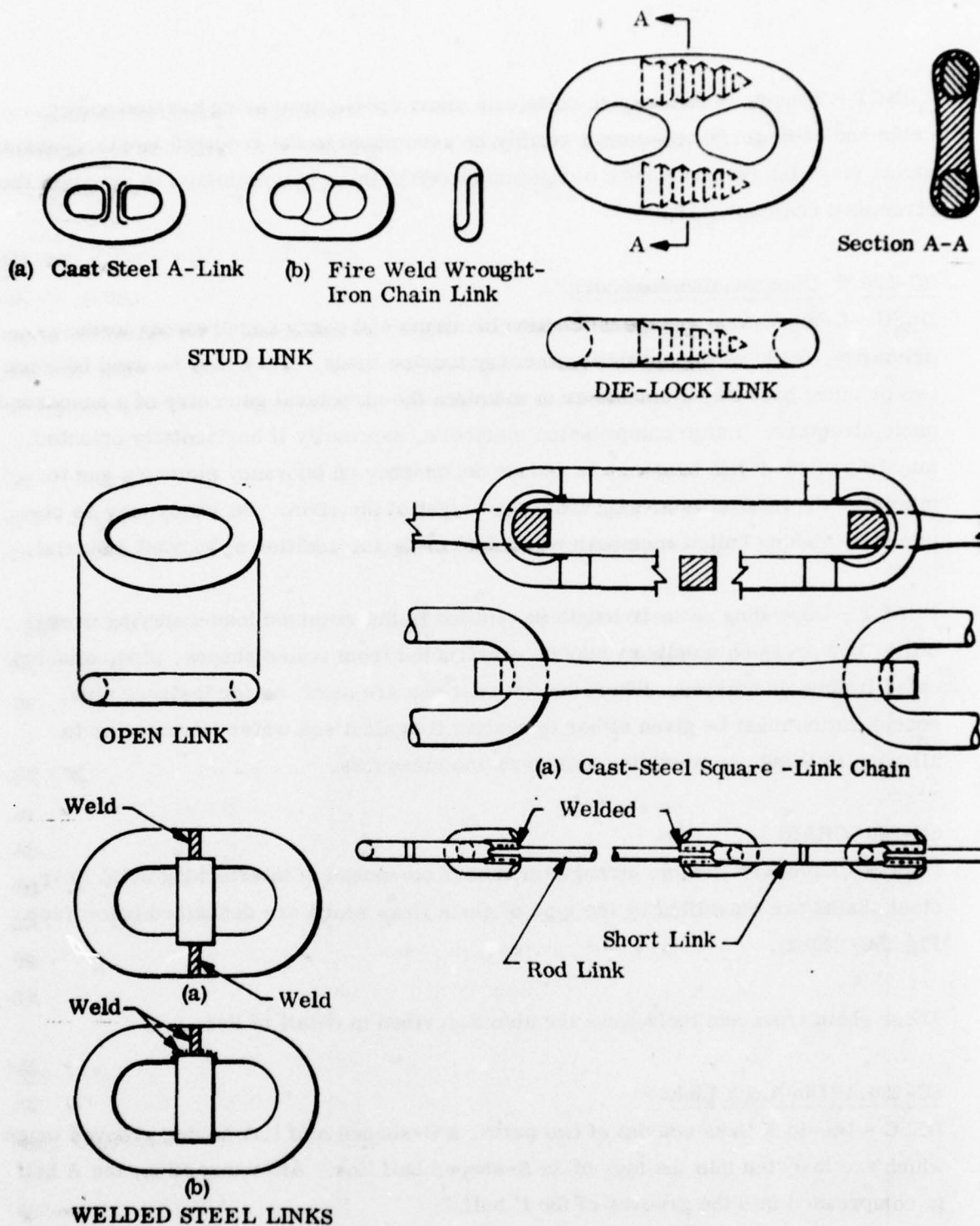


Fig. SC-200-2 Chain Links

SC-230.2 Stud Link

DESC - The stud link has a cast or welded bar across the width of the link to limit any decrease in width of the link when under load, thus increasing the permissible load before yield.

SC-230.3 Welded Link

DESC - Welded links may be either of the open or stud type but are made from bar bent to the shape of the link and butt welded either in one or two places.

SC-230.4 Cast Square Link

A cast square link is an open link having a relatively large length compared to its width and made of cast steel having a square section.

SC-230.5 Open Link

An open link has no cross bar and is therefore of lower strength than the die-lock or the stud link.

SC-230.6 Rod Link

Each rod link consists of two U's welded to a rod. This type of construction is suitable for fabrication in the field though it is not then as reliable.

FUNCT - Chain is employed in applications where a flexible tension strength member is required. Its weight and massiveness make its use throughout a suspended cable structure system impractical. Also, the area exposed to ocean currents is greater for chains than for rope so that the drag forces on the system may be excessive. However, chain can be used at the extremities of the structure, especially on the bottom, because of its capacity to withstand abuse and the fact that it can be easily connected with standard fittings and connections.

INTER - Provisions are required for the mechanical connection of the chain to other elements of the SC structure such as buoyancy elements, anchors, struts, and cables. Mechanical connection is generally made by means of the components contained in Rigging and Fittings (SC-240). Chains may interface with and either be restrained by

or restrain the Anchoring System (SC-100), Buoyancy Elements (SC-300), and other elements of the primary structure such as Struts (SC-220) and Release Devices (SC-120.3).

SC-240 RIGGING AND FITTINGS

DESC - Rigging is the process and technique of assembly and installation of the elements of the primary structure and is generally accomplished at sea during the process of deployment. As the cables, chains, and other components are connected during installation, fittings are used to make the connection.

The fittings in general are standard "off-the-shelf" hardware selected for the anticipated service and to facilitate the particular rigging operations. A wide selection of such fittings is available and the most commonly used items are defined below.

FUNCT - Fittings are used to join together segments of the suspended cable structure, to transmit load from one segment to the other, and to facilitate assembly or dismantling.

INTER - By their nature, fittings are to be found at all interfaces between major elements of the structure as well as at many connection points internal to these major elements. There may therefore be an interface at any connection between the Anchoring System (SC-100), the Primary Structure (SC-200), and the Buoyancy Elements (SC-300). Other connections using fittings will be at connection points for the Payload Accommodations (SC-400), Navigation, Warning, and Communication (SC-700), and Mechanical Protective Systems (SC-510).

SC-240.1 Link

DESC - A link is one of the segments of a chain or a structural ring to which two or more segments of chain or cable, or a pear link or round link, are connected.

SC-240.2 Shackle

DESC - A shackle is a U-shaped device having a removable pin across the open end of the U, and is utilized for connecting lengths of chain or cable.

SC-240.3 Ring

DESC - A ring is a structural member attached to the end of an anchor shank for the purpose of facilitating attachment of other system elements. (It is also a synonym for some types of link, above.)

SC-240.4 Hook

DESC - A hook is (1) a partial ring, open at the side or top, connected to the end of tackle or to a line for hoisting loads; (2) the curved metal piece fitted at the top of an upper block and used for hooking the block. Safety hooks may have a keeper device to prevent the load from jumping off the hook.

SC-240.5 Clamp

DESC - A clamp is a bolted device used to form an eye on a wire rope without the necessity of splicing and is often used with a thimble. A clamp may also be employed to connect two pieces of wire rope rapidly without having to splice.

SC-240.6 Fastener

DESC - A fastener is a padeye, bitt, bollard, chock, or other fitting attached to a hull or other structure for absorbing or distributing the loads from ropes and cables.

SC-240.7 Swivel

DESC - A swivel is a metal link arranged so that one end is permitted to revolve axially relative to the other. When inserted in a chain or cable it will prevent turns in the chain and prevent cable hocking.

SC-240.8 Thimble

DESC - A thimble is a grooved ring of metal, often elongated, to fit within a loop in a rope and prevent or relieve the rope from chafing, and also to facilitate attachment. It maintains the shape of an eye splice.

SC-240.9 Turnbuckle

DESC - A turnbuckle is a right-and-left screw link, or a link with a swivel at one end and a screw at the other, capable of being set up or slacked back, and used to tighten standing rigging, stays, etc.

SC-240.10 Stopper

DESC - A stopper is a short length of rope, secured or belayed at one end, used in securing or checking a running rope.

SC-240.11 Plate

DESC - A plate is a reinforcement welded to a deck or bulkhead and is used for distributing localized or very heavy loads into several frames. Also, a plate may be used at the intersection of two or more chains or cables to which they are shackled.

SC-240.12 Padeye

DESC - A padeye is a metal eye permanently secured to a deck or bulkhead to which a line or tackle may be shackled.

SC-300 BUOYANCY ELEMENTS

DESC - Any immersed body having excess buoyancy and thus supplying a lifting force (its weight is less than the weight of displaced water) constitutes a buoyancy element. These may be either hollow or solid with a wide range of shapes, but are frequently spherical or cylindrical (see Fig. SC-300-1).

FUNCT - Buoyancy elements may be categorized as surface floats or subsurface floats. Selection of type will depend upon considerations such as the desirability of covertness, or other operating requirements.

Buoys provide the vertical forces necessary to support the suspended cable structure and associated payload, its accommodations, and other systems. Buoyancy elements may also be integrated with and may even be the payload accommodations. Smaller surface floats are frequently used as marker buoys; this function is discussed in SC-720.

INTER - Buoyancy elements will interface primarily with the Primary Structure (SC-200) that they support. Provision will be made for the installation and, where necessary, the electromechanical connection of the Electrical Power Systems (SC-600), the Navigation, Warning, and Communication Systems (SC-700), and the Payload Accommodations (SC-400).

SC-310 SURFACE FLOATS

DESC - A surface float is a buoyancy element which, in its normal operating condition, has some part of its volume above the surface (free board). It may be moored by an anchoring system or connected to the primary structure. It can be used to support a data gathering system while drifting with the current.

Surface floats may be made from a variety of materials and have many configurations. Materials include steel, fiberglass, glass, foam or wood as required by the size of float and type of service.

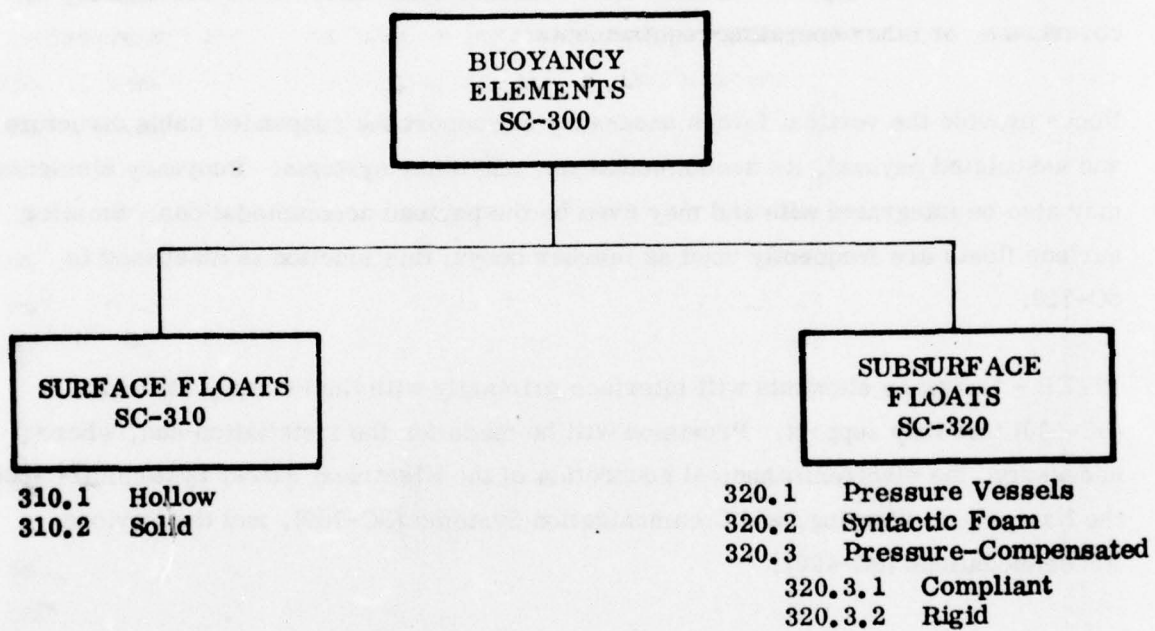


Fig. SC-300-1 Buoyancy Elements - Breakdown Structure

Configurations include spherical, cylindrical (either vertical or horizontal), spar-shaped, discus, and boat shaped, the last three configurations having relatively low drag.

Surface floats fall into two categories, hollow and solid as described in SC-301.1 and SC-301.2.

FUNCT - Surface floats provide all or part of the support for a suspended cable structure. They may also provide support for payload accommodations and may, in fact, be the payload accommodation. They will, when necessary, be the platform on or in which are installed the navigation, warning, communication, and electrical power systems.

INTER - Padeyes (SC-240.12) load distribution structure and other provisions will be made for connection to the Primary Structure (SC-200). Hatches, walkways, handrails and life support systems will be provided when necessary for boarding.

SC-310.1 Hollow

DESC - Hollow surface floats typically have a structure consisting of a thin outer shell stiffened with frames, bulkheads, stringers and decks. Smaller hollow buoys are often of monocoque construction; that is, the shell has inherent stability and does not require stiffening members. While steel is the most commonly used material, other materials are also used.

SC-310.2 Solid

DESC - Solid surface floats are usually made in smaller sizes because they are less expensive and more reliable than a hollow float. They tend to be less efficient in larger sizes in addition to being more difficult to handle and offer no opportunity for internal installation of other components and systems.

Closed cell polyurethane foam and syntactic foam with outer reinforcing members are the most commonly used materials and may include supplant wood or cork.

SC-320 SUBSURFACE FLOATS

DESC - A subsurface float is a buoyancy element which, in its normal operating condition, is always submerged. It is connected to the primary structure and moored by the anchoring system.

Padeyes (SC-240.12) load distribution structure and other provisions will be made for connection to the primary structure. While it is possible to gain access to a submerged float with special equipment, this is not common. In general, therefore, access provisions are not made except those required during manufacture and outfitting. If implantment operations require accurate depth placement, winching provisions for the mooring line may be required in or on the float.

Because they are completely submerged, all subsurface floats must resist hydrostatic pressure. The method used to react this pressure determines the type of construction used for the floats, which may be categorized as: (a) pressure vessels, (b) syntactic foam, and (c) compliant floats. These three types are described below.

FUNCT - Subsurface floats have essentially the same function as surface floats except for those functions such as marker buoy and antenna support peculiar to surface floats.

SC-320.1 Pressure Vessels

DESC - Pressure vessels are closed shells designed to withstand external hydrostatic pressure loads. Shells subjected to compression fail from instability. For all but moderately stressed or for spherical vessels they must be suitably stiffened, usually with hoops. The stiffening delays the onset of instability, ideally until the full allowable compressive strength of the material has been achieved. Stiffening is also employed in large structures to control the shape and to facilitate handling. Unstiffened structures are usually spheres or fairly small cylinders with hemi- or elliptical heads.

Pressure vessels have most commonly been made of either carbon or alloy steel as well as aluminum, fiberglass, and plastic. Glass has also been used and has high strength, but is difficult to fabricate in other than uniform and generally small sections and diameters.

SC-320.2 Syntactic Foam

DESC - Syntactic foam is a better material for subsurface floats than for surface floats because of its hydrostatic strength. This material is a composite of hollow microspheres embedded in a resin matrix resulting in a solid substance having low density, high hydrostatic strength, low water absorption, and immunity to catastrophic failure. It can be fabricated in irregular shapes.

With a bulk modulus nearly equal to that of sea water, a syntactic foam float can maintain an almost constant buoyancy with change in depth.

SC-320.3 Pressure-Compensated

DESC - A pressure-compensated float is one containing a liquid of less density than sea water and arranged so that the internal and external pressures are in equilibrium. The liquid used is frequently a hydrocarbon because of low density relative to water. Since the shell of the float is not subject to differential pressure it may be "soft," that is of relatively low stiffness. Pressure-compensated floats may be either compliant or rigid.

SC-320.3.1 Compliant

Compliant pressure-compensated floats contain low density fluid in a sealed flexible container which, by its nature, allows external and internal pressures to equalize.

SC-320.3.2 Rigid

Rigid pressure-compensated floats have a shell stiff enough to maintain its shape to react applied loads. The underside of the float is vented to sea in order to equalize pressures and the structure is suitably configured so that the interface between the internal liquid and sea water is located so that the buoyancy medium cannot escape.

SC-400 PAYLOAD ACCOMMODATIONS

DESC - Payload accommodations are equipment supports, mechanical connectors, fittings, protective enclosures, and protective components attached to a primary cable structure. These accommodations include enclosures for the payload either at the surface or submerged, together with the components for attaching the enclosures to the primary structure (see Fig. SC-400-1).

FUNCT - Payload accommodations provide for the attachment of the payload to the SC structure and for its protection from the effects of the marine environment, such as loads, motions, and pressure. The payload accommodations also provide equipment (such as fairings and damping devices) to mitigate and control those loads and motions.

INTER - The payload accommodations interface with the Primary Structure (SC-200) which supports them and with the components they support and protect. For sensor arrays this must be accomplished without impairing the functioning of either the primary structure or of the sensors.

SC-410 SEA SURFACE ENCLOSURES

DESC - Sea surface enclosures are those accommodations that are designed specifically for the support, containment, mechanical and electrical connection, and protection of components that must be located at the surface. The enclosures may be self-buoyant or they may be supported by other buoyant elements of the system. They may be sealed and dry or oil-filled and will have, as necessary, penetrators for electrical cables.

If manned access is required, provision will be made for boarding from a service boat, for entry, and for working safely when aboard by the provision of handrails, walkways, hatches, and ventilation.

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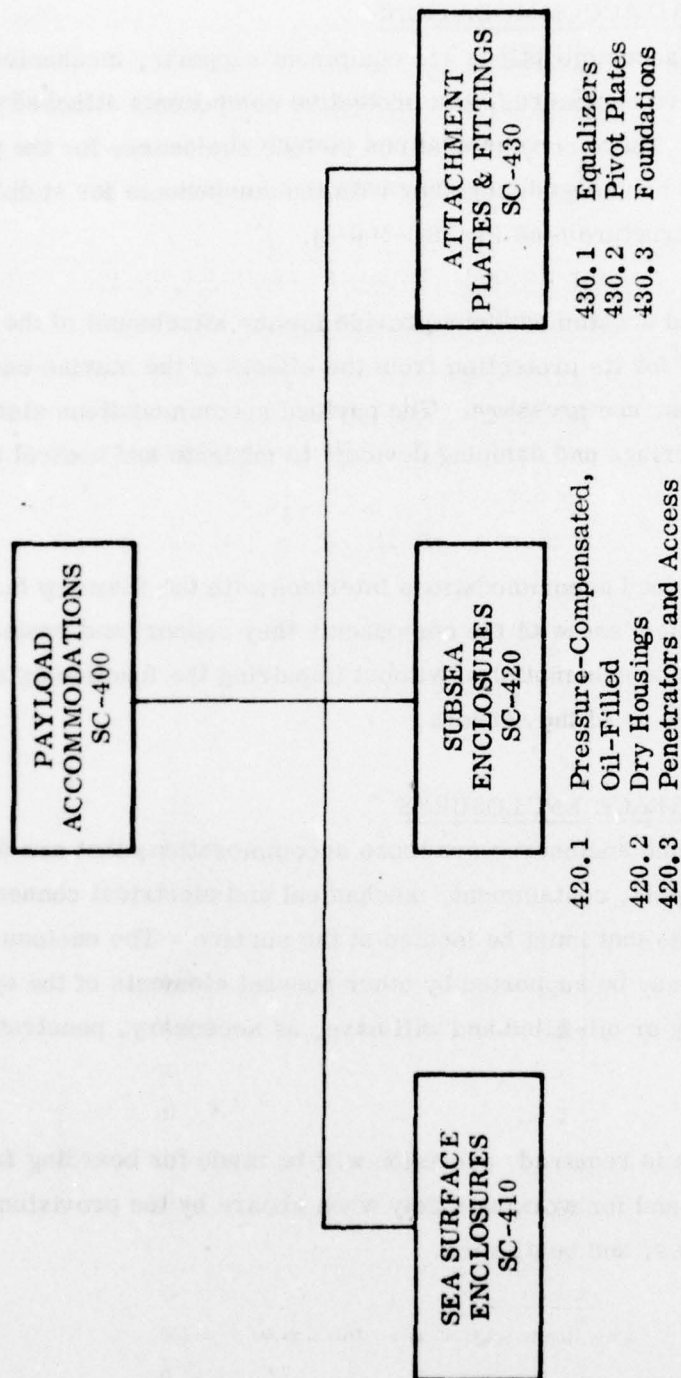


Fig. SC-400-1 Payload Accommodations - Breakdown Structure

SC-420 SUBSEA ENCLOSURES

DESC - Subsea enclosures are those accommodations that are designed specifically for the support, containment, mechanical and electrical connection, and protection of components that must be located beneath the sea surface. They may be nonpressure resistant or pressure resistant. In the former case they may be oil compensated or, less frequently, sea water flooded. Pressure resistant enclosures are rigid structures designed to withstand hydrostatic pressure.

SC-420.1 Pressure-Compensated, Oil-Filled

DESC - An oil compensated enclosure is filled with oil separated from the surrounding sea water by a resilient boundary in the form of either a flexible diaphragm or a piston. This ensures that there is no differential pressure across the enclosure boundary so that it does not have to withstand a hydrostatic pressure greater than the difference between the head of internal oil versus external sea water for the height of the enclosure. As with surface enclosures, the oil used will be selected to suit the internal components. If the components in the enclosure would not be damaged by contact with sea water, the whole enclosure may be sea water flooded to achieve the same result as oil compensation.

SC-420.2 Dry Housings

DESC - Dry housings maintain their shape when subjected to external hydrostatic pressure. Where they are used at more than very shallow depths they are generally spherical or cylindrical with spherical or ellipsoidal ends. In shallow water, less efficient shapes may be used if the associated weight penalty is acceptable. Generally dry housings contain air at surface ambient pressure. In circumstances where it is necessary to inhibit corrosion, the housing may be filled with dry air or with nitrogen (sometimes at a slight positive pressure relative to surface ambient).

SC-420.3 Penetrators and Access

DESC - Penetrators are used where it is necessary to pass electrical cables or piping through the pressure boundary. Electrical penetrators are fully described in SC-630.4. Penetrators for piping are constructed in a similar fashion to standard bulkhead connectors but having sealing provisions to suit the external pressure.

Access includes the means provided either for personnel to enter the enclosure or for installation or removal of components with subsequent resealing of the pressure boundary. Access may be necessary either during manufacturing or in the field for maintenance.

SC-430 ATTACHMENT PLATES AND FITTINGS

DESC - These items are the supports between the payload components and the supporting structure. Generally they will be conventional standard hardware and materials. Where the payload component is fragile or sensitive, provision is made for mitigating the effect of shock or vibratory loading.

FUNCT - Attachment plates and fittings support payload components in the correct location and orientation relative to the primary structure in such a fashion that excessive loads or motions are not transmitted to the components.

INTER - Attachment plates and fittings interface with the primary structure and with the payload enclosure or other component being supported.

SC-430.1 Equalizers

DESC - Equalizers are links or other connecting hardware, commonly known as whiffle trees, which are designed to distribute a concentrated load from an enclosure or other components into the supporting structure.

FUNCT - Equalizers are used to distribute the applied point at the supporting structure.

SC-430.2 Pivot Plates

DESC - Pivot plates are a particular form of attachment plate designed to permit rotational motion of the enclosure or its connecting structure relative to the primary structure.

FUNCT - Pivot plates allow the enclosure to adopt or maintain its orientation when the primary cable structure deforms under the influence of external environmental conditions.

SC-430.3 Foundations

DESC - Foundations comprise the structure to which the payload is attached and which in turn is secured to the payload enclosure.

FUNCT - The foundation transmits and distributes load from the payload to the enclosure. Where required, it isolates the payload from loads or vibrations transmitted from the structure and it permits adjustment of the orientation of the payload relative to the enclosure and thus to the primary structure.

SC-500 PROTECTIVE SYSTEMS

DESC - Protective systems are those devices or coatings and techniques which are interposed between the FOF and the environment or other structures or vessels. They are categorized as (a) mechanical, such as fenders; (b) coatings, such as anticorrosion or antifouling paints; and (c) cathodic protection, such as sacrificial anodes or other electrolytic protection (see Fig. SC-500-1).

FUNCT - Protective systems provide a system with immunity or at least mitigation of the effects of corrosion, biofouling, or collision.

INTER - The principal interface of protective systems is with the element being protected, which involves selection of a compatible system. Fenders are selected and located for the anticipated service as, for example, tying up a workboat, or working of one structural element against another.

Basic materials for construction and service components should be selected, in so far as is possible, to be compatible with the environment, and when in intimate contact with each other. Selection is directed toward the choice of materials which in combination yield a lower galvanic difference than the value at which corrosion occurs. Suitable coatings must be provided for incompatible materials to provide isolation. Compatibility of coatings on different components should also be considered.

SC-510 MECHANICAL (FENDERS)

DESC - A fender is a resilient, energy-absorbing device attached to the external surface of the suspended cable structure. Fenders may be separate items attached or hung at intervals around a buoyancy element or may be continuous.

Other mechanical protection may consist of a boom or similar structure between some surface float and an adjacent boat.

FUNCT - Fenders protect the SC structure from mechanical damage due to collision, impact, or working of one part of the structure against another.

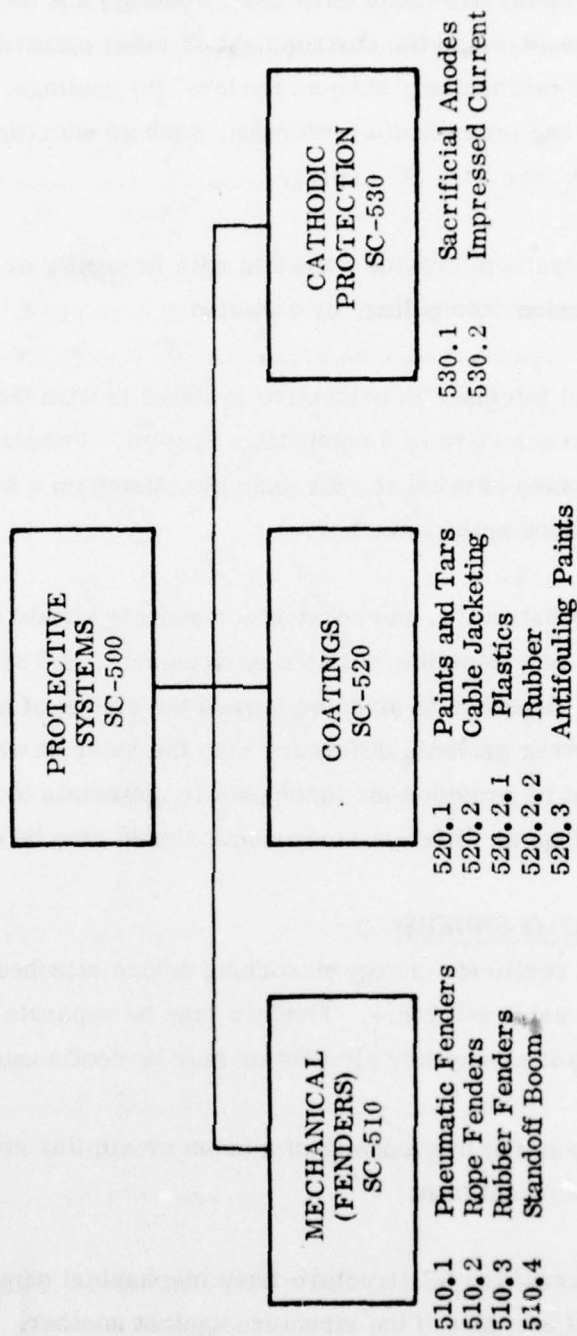


Fig. SC-500-1 Protective Systems - Breakdown Structure

SC-510.1 Pneumatic Fenders

Pneumatic fenders are fenders whose resiliency or ability to sustain crushing loads is obtained by air contained within a flexible casing. The air may be in a sealed compartment or the casing may be vented so the volume is reduced as air is forced out.

SC-510.2 Rope Fenders

Rope fenders are fenders constructed of rope that has been knotted, plaited, or otherwise formed to rest against an SC structure and absorb the impact of adjacent vessels.

SC-510.3 Rubber Fenders

Rubber fenders are fenders fabricated from rubber of a consistency and in a form suitable for absorbing the impact of an adjacent vessel. They may be solid or hollow and air filled or water filled and vented.

SC-510.4 Standoff Boom

DESC - A standoff boom is a spar, one end of which is attached and pivoted at or near the sheer strake or the corresponding structure on a surface float. Its other end is rigged outboard and has provisions for a workboat or other small boat to tie up. Rigging will allow the boom to be brought alongside or swung outboard.

FUNCT - Standoff booms protect structures by providing a means for attachment of a workboat on a buoy such that collision is unlikely, thereby precluding impact damage.

SC-520 COATINGS

DESC - Coatings comprise (a) paints or other materials applied as a liquid to the surface of the SC structure by brush or spray; (b) metals applied by dip, spray, or electrolytic action; and (c) flexible plastic or rubber jacketing applied to ropes or electrical cables, usually by extrusion.

FUNCT - Coatings will protect the structure from corrosion or biofouling and may also form some protection from fishbite.

SC-520.1 Paints and Tars

DESC - Finishes for marine structures include organic and inorganic zinc-rich paint coatings, epoxy, polyurethane, vinyl, and coal tar paint coating systems.

FUNCT - Coatings are designed to exclude direct contact with the environment and prevent corrosion attack of FOF components.

SC-520.2 Cable Jacketing

DESC - Cable jacketing consists of one of a number of materials such as plastic or rubber extruded over ropes or electrical cables as a durable, noncorrosive coating.

SC-520.2.1 Plastic

Plastic jacketing is available in various materials such as polyvinylchloride (PVC), polyethylene, polyurethane, or polypropylene. Polyethylene is relatively light and polypropylene is positively buoyant, making them attractive choices where long cable lengths are necessary.

Some jackets (valley-filled) fill the space between strands and are used where a rope is gripped. Other jackets, such as the proprietary Macwhyte Spacelay, have all interstices between strands plastic-filled, which gives complete corrosion protection and a smooth surface.

Both steel and synthetic lines may be jacketed as a protection against fishbite. Bright colors are to be avoided.

SC-520.2.2 Rubber

These are used for mechanical protection and insulation of electrical cables. Rubber includes elastomeric materials such as neoprene, which are used for the same purposes and as anticorrosion coverings.

Neoprene rubber sheet material bonded in place and containing cuprous oxide and/or organo-tin compounds is also used to encase structures. The materials are designed to prevent attachment of marine organisms to the structures in the sea by the slow release of toxic material from the coating into the surrounding sea water.

SC-520.3 Antifouling Paints

DESC - Antifouling paints are paint systems that contain specially selected chemicals and are applied in the conventional manner.

FUNCT - The chemicals and their action/function are as described in SC-520.2.2.

SC-530 CATHODIC PROTECTION

DESC - Cathodic protection is a means of changing the electrical potential of a structure immersed in salt water in a cathodic direction (i.e., making its voltage more negative). Two methods are used: (a) provision of sacrificial anodes, or (b) use of impressed electrical current.

SC-530.1 Sacrificial Anodes

DESC - Sacrificial anodes are metallic elements of aluminum, zinc, or magnesium selected to set up a galvanic cell in sea water. The structure is the cathode of the galvanic couple. Protective current flows to the structure from the anode, which corrodes at a rate that is governed by the size of the structure and the materials used.

FUNCT - Cathodic protection operates by ensuring that material loss due to electrolytic action in sea water is confined to an anodic material placed there for that purpose and not from the structural material.

INTER - Installation of cathodic protection should provide for access and consideration of the type of structure (e.g., size, material, construction, and painted area of the structure) to determine the amount and location of anode material. Complex configurations in general require more anodes than an open uniform structure such as a ship's hull. The size, the material in construction, and the configuration of the structure, will determine the type and number of anodes that are required.

SC-530.2 Impressed Current

This technique is the use of an external power source, a permanent anode such as silicon iron, graphite, and platinum, and a reference electrode to change the electrical potential of a structure in sea water. The change in potential is in the cathodic

direction (i.e., from -0.6 to -0.8 volts) according to the sea water galvanic series. The reference electrode measures the potential of the structure and thereby determines if corrosion protection is being achieved. The size, material of construction, and configuration of the structure will determine the type and number of anodes and reference electrodes required.

INTER - The user of impressed current systems must consider the potential problems of over-protection where the protection level may cause loss of protective paint coating adhesion. There also may be hydrogen embrittlement of any high strength component in the FOF exposed to the protective current of the system.

SC-600 ELECTRICAL POWER SYSTEMS

DESC - Electrical power systems include power sources, controls, and distribution systems. The types of electrical power systems available for use in suspended cable structures are self contained or shore connected. Optimization of these systems will tend toward high efficiency, long life, lower power drain, and high reliability with minimum maintenance (see Fig. SC-600-1).

FUNCT - Electrical power systems provide, regulate, and distribute electrical energy to operate the payload and to support functions of the suspended cable structure.

INTER - The capacity of the electrical power system is usually dependent upon the requirements of the Payload (SC-400), impressed current Cathodic Protection (SC-530), and Navigation, Warning, and Communication Systems (SC-700). Applicable systems will usually be limited to those which are self-contained within the elements of the structure except for shore powered systems including the consumables which provide the total energy supply for the structure. The type of power system will depend upon the optimization of the system with respect to the requirements of the energy consuming loads. Operating life of the system will probably be limited by the total energy available.

SC-610 POWER SOURCES

DESC - These include all equipment used for the generation of electrical power by the direct conversion of chemical and electromagnetic or atomic energy or for providing power from shore based generation systems. Except for shore power, sources will be self-contained, and will be generated either by chemical or by nuclear reaction. Power will be available primarily as dc and, for long life structures, will be available in tens of watts (see Table SC-600-1).

FUNCT - Power sources provide the energy to operate the payload and other support and utility systems required for the operation of a suspended cable structure. The power source must have the capacity to provide the steady state and peak power required by the payloads, including Protection System (SC-530) and Navigation, Warning, and Communication Systems (SC-700), throughout the useful life of the facility.

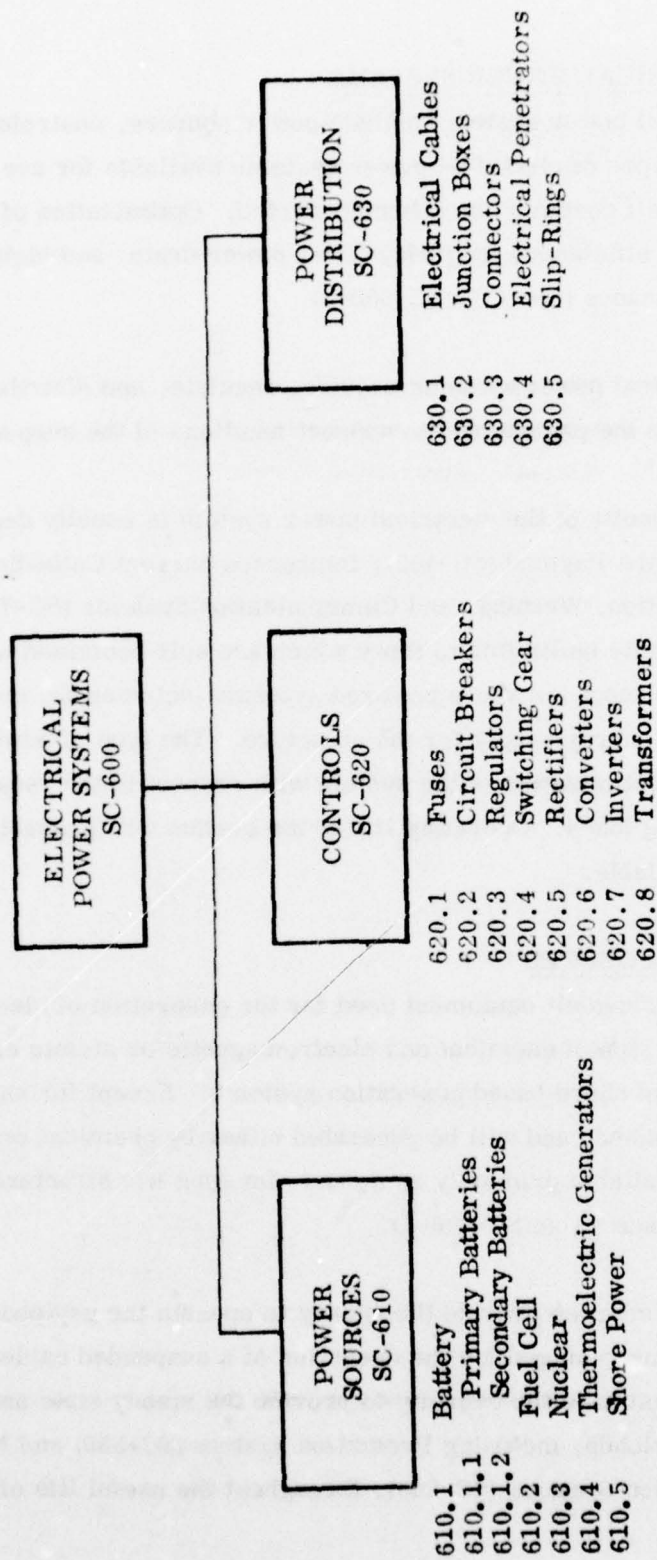


Fig. SC-600-1 Electrical Power Systems - Breakdown Structure

Table SC-600-1
POWER SOURCES

| Power Source Type | Charging Capability | Energy Density | Comments |
|--|---------------------|-----------------------|------------------------------------|
| 1. Batteries | | | |
| Primary | Not Rechargeable | 30-60 w-hr/lb | Subject to aging |
| Dry Cells | | 30-2000 w-hr/lb | Reaction products |
| Sea Water Activated | | 10-45 w-hr/lb | Venting required |
| Secondary | Rechargeable | low energy density | Power reduction at low temperature |
| Wet Cells | | | |
| Dry Cells | | | |
| 2. Fuel Cells | ---- | 6-8 w-hr/lb | Reaction products |
| 3. Radioisotope Thermoelectric Generator | ---- | 10^2 - 10^5 watts | |
| 4. Nuclear Reactor | ---- | 10^4 - 10^7 watts | |

INTER - The primary functional interface is between the power source and the electrical load through Power Distribution (SC-630) and Controls (SC-620). The variation of the voltage as the power source becomes exhausted over the lifetime of the structure will primarily determine the requirement for Regulators (SC-620.3).

SC-610.1 Battery

DESC - A battery is an arrangement of individual cells connected in series or parallel. It includes all units used for the direct generation of electrical energy by chemical reaction methods. Batteries are divided into two major classes: 1) primary, 2) secondary.

FUNCT - Batteries provide electrical energy to the suspended cable structure in circumstances where relatively light loads are required to supply power intermittently or over a long period of time.

INTER - For elements of the suspended cable structure which require low power drains, batteries may be provided as integral parts of isolated functional units such as elements of the Navigation, Warning, and Communication Systems (SC-700). Batteries are also used for power sources for major system elements in suspended cable systems. Under circumstances of high peak load requirements, in conjunction with radioisotope generators or shore power systems, a battery would be used as a load-leveling device. Depending upon the characteristics of the system, the battery can be housed in the Subsea Enclosure (SC-420) protected from ambient pressure, or could be exposed to ambient pressure through a fluid compensating system which prevents sea water from entering the battery.

SC-610.1.1 Primary Batteries

DESC - Primary batteries are nonrechargeable batteries which generate electricity as a direct byproduct of a chemical reaction. These batteries are self-contained, are often sealed, and in their initial state they require no energy input to activate them. They are comprised of one or more cells connected in series or parallel. Some primary batteries have a limited capacity to be rejuvenated by an electrical charge once

their initial energy is depleted. Primary batteries that may be used with suspended cable systems include:

- a) Carbon zinc batteries - Based on the Leclanche cell, also known as dry batteries. There is a wide variety of sizes, packages, and electrical characteristics. They are readily available and economical.
- b) Alkaline batteries - This is a more advanced, high-performance form of dry cell that can produce electrical power at low temperature and can also be obtained in rechargeable form.
- c) Zinc-Air - The unsealed unit consumes air and also uses an electrolyte, thereby requiring attention to physical orientation. It has a high power weight and power cost ratio. Where air is not available it can be obtained in zinc-oxygen form as sealed units.
- d) Magnesium-sea water - Suitable for low power drains over long periods of time. Direct interaction with the sea must be carefully considered. Unlimited shelf life before activation.
- e) Lithium-sea water - Suitable for high power drains over short periods of time. Lithium anodes are consumed and need replacing for reactivating the battery. Battery produces byproducts of hydrogen-lithium dioxide and heat, which must be allowed for in system design. It is probably most applicable to suspended cable systems where activation of the battery takes place when the system is deployed.

FUNCT - A primary battery produces electrical power directly using a combination of specific chemical elements. Its function is to provide a dc electric power to sources internal and external to the structure where a recharging capability is unnecessary or impossible.

INTER - Battery power sources and their housings should be designed to operate for the life of the suspended cable facility. Selection of the appropriate type of battery will

depend upon the characteristics of the loads such as minimum and normal power drain as well as peak power requirements, and in some cases the standby life of the battery.

SC-610.1.2 Secondary Batteries

DESC - This category of batteries includes units that are charged with electrical energy stored to be released later. A battery comprises one or more cells interconnected in series or parallel. Secondary batteries can be charged several hundreds of times and can deliver hundreds of amperes of current and include:

- a) Lead acid - Widest form of secondary battery used for high discharge current requirements usually configured in series cell arrangements in 12 volt and 28 volt batteries.
- b) Nickel-cadmium - Available in many series or parallel configurations in a variety of voltage and power levels. Has good performance and temperature characteristics.
- c) Silver-zinc - Has high energy density but is expensive to produce due to the use of rare metal.

FUNCT - Secondary batteries are used to provide ac electrical power to sources internal and external to the suspended cable structure when secondary batteries provide the most advantageous characteristics. Although charging may not be a requirement, secondary batteries may be used when their individual characteristics provide the best solution to a requirement. For example, lead-acid batteries provide power at low cost with high weight; silver-zinc batteries provide high power density but also at high cost.

SC-610.2 Fuel Cell

DESC - A fuel cell is an assembly of two electrodes separated by an electrolyte which produces dc electricity by the chemical action in the electrolyte. In this respect, they are similar to batteries; however, the electrodes are represented by porous catalysts which provide a chemical reaction between the fuel and the electrolyte. Fuel cells

must be continuously supplied with fuel to operate. Several types of fuel cells are suitable for use in suspended cable facilities. They include:

- a) Hydrogen-oxygen (hydrox - both gaseous and liquid)
- b) Hydrazine-oxygen
- c) Hydrogen-propane-oxygen
- d) Ammonia-oxygen

FUNCT - Fuel cells provide electrical power to the suspended cable facility by conversion of continuously supplied chemical elements into dc electricity.

INTER - Because of their cost and complexity, and their requirement for high pressure or cryogenic fuel storage, fuel cells would only be used in circumstances which require their special characteristics such as a high power-to-weight ratio. Since provisions cannot be made for servicing of the fuel cell and fuel storage systems, special attention must be given to fuel storage and high reliability. In most instances, cryogenic storage would not be suitable, leaving the only alternative high pressure gas storage, which would limit the advantage of fuel cells.

SC-610.3 Nuclear

DESC - Nuclear systems produce power by producing heat. Heat from radioisotopes is used to power Thermoelectric Generators (SC-610.4) for power sources up to hundreds of watts. Higher power ranges can be attained by employing nuclear reactors using steam or gas as a coolant. These can generally remove as much energy as is stored in the reactor.

FUNCT - A radioisotope generator would be used to produce a relatively modest level of power where extremely long life without servicing is required and where the cost of the system is justified. Other types are used where high levels of power are required.

INTER - A radioisotope power source could be used where extremely long life is not available from other power source and where the total lifetime of the suspended cable facility is dependent upon the source of power. Extreme circumstances would be

required for use of this power source because of its high cost and low power output. Radioisotopes require special casings to minimize radiation hazards. Provisions must be made for disposing of waste heat from the radioisotope power source if environmental conditions prevent using the site as a heat sink.

SC-610.4 Thermoelectric Generators

DESC - A thermoelectric generator is a mechanical assembly of two dissimilar metals at different temperatures which produce small amounts of dc electricity by direct interaction of metals at the junction. A combination of cells in stacks can provide tens of watts of power and a few volts. Fuel heaters such as propane or radioisotope are generally used. These units are relatively inefficient but are characterized by long maintenance-free operation.

FUNCT - Thermoelectric generators can produce modest amounts of power for a suspended cable facility over a long period of time with high reliability and with few byproducts.

INTER - A thermoelectric generator has few special interface requirements. If a hydrocarbon fuel is used in a suspended cable facility, special consideration must be given to the fuel system and the oxidizer system because of high pressure requirements. In a suspended cable system, the heat source would normally be a radioisotope. The low efficiency would probably preclude the use of hydrocarbon heat sources as an energy supply. The systems are relatively inefficient when the entire system weight and cost per unit of electricity is concerned. Since there are no moving parts, very high reliability can be achieved.

SC-610.5 Shore Power

DESC - Shore power involves a submarine cable which connects the suspended cable structure to a source of power or a distribution system located on land.

FUNCT - Shore power provides power to the suspended cable system under circumstances where it is desirable because of cost, reliability, or total energy requirements to power the facility from shore.

INTER - In those situations where power is provided from shore and there is a requirement for transmitting data to shore, a cable should be provided that will perform both functions. Provisions must be made for protecting the cable from the consequences of traffic or fishing in the area, and providing adequate shore landing and interconnection with the power source on shore. At the suspended cable structure, the primary interface is with Power Distribution Systems (SC-630) and the Electro-magnetic System (SC-730).

SC-620 CONTROLS

DESC - Control equipment has a variety of forms depending upon the function and the size. It may be solid state, gas discharge, or rotary. The power capacity ranges from milliwatts to megawatts. Sizes range from fractions of an inch to many feet in dimension. However, for the suspended cable facility, the size and power level will be limited.

FUNCT - Control equipment converts electrical energy from the source to the proper frequency, voltage, current, or impedance level for use by a load, and provides protection of the power source from malfunctions in the distribution system or in the load.

INTER - Controls must connect to and match the power level of the Sources (SC-610), the Power Distribution Systems (SC-630), and all of the loads including Payload Accommodations (SC-400).

SC-620.1 Fuses

DESC - A fuse is a fuseable link of metal which melts and disconnects the load from the source when a specified current level is reached. Current levels range from milliamperes to hundreds of amperes.

FUNCT - Fuses prevent damage to systems by disconnecting a faulty system element from the system or by limiting the power dissipation in active system elements to safe levels.

INTER - Because fuses require replacement, the only candidate location for fuses with respect to a suspended cable system is at the shore end of a Shore Power System (SC-610.5). Ratings of fuses must be established to clear faults before damage occurs, but must not melt when subjected to normal overloads or transients. Where fuses are used for protection, the current rating of each individual load must be assessed in order to determine the size of the fuse for the protection desired. Fuses are not as expensive as circuit breakers. A fuse operated in extremely high ambient pressure conditions may open at current levels lower than specified. In certain special circumstances in the suspended cable systems, where gradual degradation of the total system can be tolerated, fuses may be placed throughout the system to disconnect faulty elements from the primary system even though this permits operation of the primary system only at reduced efficiency. This would only be used where degraded operation would be acceptable.

SC-620.2 Circuit Breakers

DESC - A circuit breaker is a mechanical switch that automatically disconnects the load from the source when a specified current level is reached. Circuit breakers can be made to operate at milliwatt levels with power levels up to megawatts. Voltage levels range from millivolts to kilovolts.

FUNCT - A circuit breaker prevents damage to the system or to the load by disconnecting faulty system elements from the system or by limiting the power dissipated in the active system elements to safe levels.

INTER - While circuit breakers are more expensive than Fuses (SC-620.1), they provide a wide range of flexibility of protection, and in suspended cable systems they permit numerous trials and reconnection of an intermittently faulty element. They can be made to operate with very low ground fault current levels with operating power current levels many orders of magnitude greater than the ground fault level. Circuit breakers can be designed to operate remotely and in some instances can be synonymous with Switching Gear (SC-624). Because the sensing elements of circuit breakers can be designed to recognize the nature of transients and differentials from abnormal overloads, the protection afforded to both equipment and personnel can cover a wide

range of circumstances. A suspended cable structure that is provided with Electro-magnetic Communications Systems (SC-730) can, when faults have occurred, have circuit breakers commanded to provide repeated attempts to clear the fault or bypass faulty elements of the system.

SC-620.3 Regulators

DESC - Regulators may be separate components or may function as an integral part with other components or elements such as transformers, converters, or inverters. Operation may be manual or automatic, with power capacity ranges from milliwatts to megawatts and may be a mechanical device such as an adjustable transformer, or may be solid state. Regulation capability is usually specified as a percent of input or output nominal voltage within a tolerance specified as a percent of nominal.

FUNCT - A regulator adjusts and controls voltage and frequency of current within limits established by the requirements for the load.

INTER - Input and output voltage, frequency, and power levels must be compatible with sources and loads throughout the suspended cable structure. The regulation capability must be adequate to cover the expected operating conditions. Within suspended cable structures, regulators would be used for Payloads (SC-400) where sensitive to voltage variations or where Power Sources (SC-610) fluctuate over wide voltage ranges because of degradation of the energy source over the life of the facility. Some regulators are designed to protect the source from load short circuits by current limiting. Higher efficiency and lower capital costs result when regulation is provided in conjunction with other components or elements. Regulators can be designed to regulate any predetermined distance from the source. In the case of Shore Power Systems (SC-610.5), on-shore regulators would be designed to provide regulation at the load within the suspended cable structure.

SC-620.4 Switching Gear

DESC - A switch is a mechanical or solid state device that opens or closes conducting paths for electrical energy. A relay is a specialized class of switch in which activation is achieved through an electrical signal. Activation of a switch may be manual or powered. Relays may be remotely operated. Operating functions range from simple

on-off to complex matrices of both sequential or parallel operation. Power capacities range from milliwatts to megawatts. Voltage ratings range from millivolts to kilovolts. High-power switches are usually oil immersed.

FUNCT - A switch connects or disconnects a source of electrical energy for one or more loads. Switching would be used in suspended cable structures to control the distribution of electrical power to the various distribution elements and to loads situated throughout the facility.

INTER - Power voltage and current ratings must be compatible between sources and loads. Characteristics of some loads require arc suppression in switches. Contact resistance in some switches increases for very low current applications to the extent that special provisions such as mercury wetted or mercury pool contacts may be required. Where shore control is provided for suspended cable systems, the method of actuation and identification by operating personnel should be considered in the placement of those switches on control panel layouts. Manually operated switches would normally not be used in the suspended cable facility except as actuating devices for initial implantment. Automatic or remote switching provisions would normally be made in this type of facility.

SC-620.5 Rectifiers

DESC - Rectifiers conduct electrical current in only one direction. Halfwave rectifiers, when connected to an alternating current source, conduct on one-half the current cycle. Full-wave rectifiers are configured so that current flows on both halves of the current cycle. Rectifiers are available for multiphase power.

FUNCT - A rectifier changes ac to dc where the primary source of power in the suspended cable facility is ac and some portion of the payload or other load requires dc.

INTER - Except for signal applications and control applications, rectifiers would probably not be used extensively in suspended cable systems. Since the power sources are normally dc, they could be used in some circumstances where conversion from dc to ac has already been made and a subelement operates at a different dc voltage level.

Interference is generated in rectifiers which may be reflected into the source and other equipment as well as loads. Provisions must be made for interference in the connecting devices or specifications for interference controls must be applied.

SC-620.6 Converters

DESC - For suspended cable facilities, converters would normally be composed of the chain of devices including a transformer, rectifier, regulator, chopper, and transformer chain. They would normally be solid state devices and be relatively small in size, measuring a few inches on each side. Power capacity would be in the tens of watts.

FUNCT - A converter changes the frequency of ac source for distribution systems to a frequency required in the operation of specific loads that are not compatible with the source frequency.

INTER - Input and output frequency, voltage, and power levels must be compatible with the electrical power sources and loads. Interference may be generated in this equipment and may be reflected into the source and into other equipment as well as loads. Provisions must be made for interference control in the connecting devices and specifications for interference control must be applied. In order to maintain the high efficiency required in the suspended cable systems, converters would only be used in unusual circumstances.

SC-620.7 Inverters

DESC - These devices in suspended cable systems would normally be solid state. They are a few inches long on each side and the power capacity would range in the tens of watts.

FUNCT - An inverter matches the characteristics of a power source to a load by changing dc to ac and/or changing the voltage level where the primary source of power in the FOF is direct current and some portion of the load requires alternating current.

INTER - The inverter would probably be used in conjunction with off-the-shelf equipment used in the suspended cable structure where the equipment is designed to use 60 Hertz dc power or 400 Hertz ac power. Input and output frequency voltage power levels must be compatible with the sources and loads. Interference is generated in this equipment which may be reflected into the source and other equipment as well as loads. Provisions must be made for interference control in connecting devices and specifications for interference control must be applied. Inverters introduce inefficiencies into the system and an aggressive search for alternatives in suspended cable structures should be conducted.

SC-620.8 Transformers

DESC - Transformers are constructed of primary, secondary, or multiple coils wound on laminated silicon steel magnetic cores. Sizes vary from fractions of an inch to many feet. Power ratings vary from milliwatts to megawatts. Operating frequency is usually 60 Hz in the United States, 50 Hz in many foreign countries, and 400 Hz in special applications.

FUNCT - A transformer changes the level of voltage current or impedance of ac systems.

INTER - In the suspended cable facility, transformers would generally be used in the communication or data transmissions system (SC-730). Since power distribution systems in suspended cable facilities are normally dc, transformers would not be widely used in suspended cable facilities, except as an element within a Converter (SC-620.6) or in an Inverter (SC-620.7).

SC-630 POWER DISTRIBUTION

DESC - Power distribution systems are composed of cables, wires, connectors, and junction boxes related to the distribution of electrical energy through a facility.

FUNCT - Power distribution systems distribute electrical energy from the power source to the loads throughout the suspended cable structure.

INTER - The power distribution system must provide at least the capacity to supply the peak requirements of the system loads usually found in Payload Accommodations (SC-400), Protective Systems (SC-500), and Navigation, Warning, and Communication Systems (SC-700) from Power Sources (SC-610). Normally the distribution system capacity decreases as the system branches toward the loads. Tradeoff should be made between initial installation cost of distribution capacity and line losses, as well as consequences of regulation requirement at the load.

SC-630.1 Electrical Cables

DESC - Electrical cables consist of 1) a center core of single or multiple conductors insulated from each other, 2) an insulating jacket, 3) sometimes electrical or magnetic shields, 4) armor for protection and/or strength, and 5) an outside cover. Power cables differ in size and number of wires in the core conductors as well as the insulation between these conductors and the external environment. Electrical cables associated with suspended cable systems would normally combine the functions of transmission of power and transmission of data or control signals. Electrical cables from shore installations to suspended cable structures whose primary purpose is data acquisition would employ coaxial cables which consist of a center conductor/strength member covered by a dielectric material that is enclosed with a conducting sheath and protected from the sea by a plastic sheath. For installations in shallow water and close to shore the cable would be single or double armored and the strength member incorporated in the armor rather than the central conductor. Other types of electrical cables used in suspended cable systems contain various combinations of coaxial and twisted pair circuits as well as power conductors. Conductors in cables are usually copper and aluminum, sometimes with a copper cladding over steel where strength is required. The cable jacket can be lead, polyethylene, rubber, or other suitable substance. In some instances, two layers of armor are spiral wound in opposite directions and the armor in turn may be covered with an additional jacket.

FUNCT - Cables are used to transmit power or signals to and from the FOF or to its various elements.

INTER - The power level requirements of the system will establish the conductor size and the insulation design. Since the practical range of cable characteristics is limited, the terminal equipment and the cables should be designed as a system to ensure compatibility, efficiency, and reliability. Requirements for protection from dragging anchors, trawls, and other hazards may determine the requirement for protection of armor. The addition of armor adds a considerable amount of tensile strength to the capability of a cable. Armored cable would probably be used rarely as an internal or integral part of a suspended cable structure. The cost of heavily armored cable is considerably higher than unarmored cable.

SC-630.2 Junction Boxes

DESC - Junction boxes are terminal points for cable mains and branches. They can be metal or nonmetallic of various sizes and shapes, sealed or unsealed, with provision for entry of the cables and internal provisions for internal connections of the cables. Some means of attaching the cable to the junction box is usually provided to avoid putting strain on the cable conductors. Explosion proof or vapor proof junction boxes are provided with gaskets or other sealing devices. Underwater boxes can be pressure and water proof to the hydrostatic head required or can be pressure compensated along with the cables or system attached by filling with a fluid, usually oil, connected to compensators for pressure changes.

FUNCT - Junction boxes provide a protected location for attaching branching circuits to main distribution cables within the FOF. Sometimes fuses or circuit breakers are located in the junction boxes to provide the main distribution protection from faults in the branching circuits.

INTER - The openings in the junction boxes and attachments to the Electrical Cables (SC-630.1) and the Primary Structure (SC-200) must be compatible with the size of the cables utilized, and internal connections must be compatible with the size of the conductors. Junction boxes may be integral with Buoyancy Elements (SC-300). Where the junction box is a pressure capsule, waterproof Electrical Penetrators (SC-630.4) must be used and may incorporate disconnects.

SC-630.3 Connectors

DESC - Connectors for suspended cable structures are of two types - those within protective enclosures and those exposed to the sea environment. Enclosed connectors may be any of the common or approved types used in shore facilities. Those that are exposed to the sea are of special design and some may be connected or disconnected underwater. Connectors are sealed to cables through molded rubber or plastic joints or through oil-filled seals. O-rings, pressure seals, or grease filling are used to prevent entry of the water into the connector. Various strength members must be carried across the connector joint; the connector shell usually provides the strength. Where cables must be connected and disconnected under water, methods of wiping and/or filling the cavity as the connection is made are usually employed. In some instances, grease or heavy oil is pumped through the connector cavity to remove residual water or moisture.

FUNCT - Connectors join the cables and equipment to the power or signal distribution system and provide a means of joining conductors within the distribution system so that the distribution system can be branched, maintained, installed, or altered to provide power at the appropriate elements of the suspended cable structure.

INTER - Cables should be designed so that incompatible circuits cannot be joined. It should not be possible to join cables carrying different circuits. Connectors should be compatible with cable size and should be designed to operate in the environment. For installations where large pressure variations are encountered, the cable connector junction should be "hard potted" to prevent fatigue of the cable wires by movement which occurs with pressure cycles.

SC-630.4 Electrical Penetrators

DESC - Electrical penetrators consist of electrical conductors extending from the internal pressure capsule or container through the wall to the outside of the container. The conductor is usually imbedded in rubber insulation, plastic, or glass, which serves the dual purpose of providing the pressure seal and insulation. Power capacity ranges from small signal conductors to large heavy power conductors. Conductors are usually grouped and become an integral part of a connector on either side of the hull.

FUNCT - Electrical penetrators transfer electrical signals or power through the pressure boundary.

INTER - Conductor sizes should be compatible with the current carrying capacity required for the function on either side of the pressure boundary. The penetrator should be compatible with connecting Electrical Cables (SC-630.1) or Connectors (SC-630.3). Since suspended cable structures are expected to remain in place for extended periods, special care should be taken to ensure compatibility of the hull materials and the penetrator and the integrity of the penetrator connector cable system at the required depth of operation. Design tradeoffs should be made between the ease of assembly and implantment associated with the use of connectors versus the permanence of direct cable penetrator interface and the increased difficulty of assembly and implantment.

SC-630.5 Slip-Rings

DESC - Slip-rings are conductor rings connected to conductors mounted on a shaft. Brushes or contactors are provided for each ring and are separately connected to the termination of other conductors mounted separately from the shaft. Materials vary widely depending upon the current-carrying capacity of the slip-ring system and the noise requirements of each of the circuits. Slip-rings are generally made in integral assemblies for underwater application and have O-ring or wiper seals to protect the unit from the environment. Where ac power or signals are used, electromagnetic coupling such as coaxial coils may be used.

FUNCT - Slip-rings transfer electrical power or signals across a rotating interface which must be allowed to rotate an indefinite number of turns in either direction.

INTER - In some circumstances where Payloads (SC-400) or other devices must be coupled electrically across Swivels (SC-240.7), a slip-ring would probably be used for simple circuits which can tolerate inefficiency across the interface. An electromagnetic slip-ring can be used because of its advantage of greater reliability and greater tolerance to leakage and fouling. Electromagnetic slip-rings are especially susceptible to stray electromagnetic fields while contactor-ring elements are subject to deterioration of the contact interface through wear and corrosion.

SC-700 NAVIGATION, WARNING, AND COMMUNICATIONS SYSTEMS

DESC - Navigation, warning, and communication systems are incorporated in a suspended cable structure deployed for overt operation to permit detection, location, and identification of the facility by vessels in the area and to permit communication. They can generally be divided into three classes - acoustic, visual, and electromagnetic - as shown in Fig. SC-700-1. Each of these systems has a defined range of effectiveness for navigation, warning, or communication and requires the use of compatible equipment on vessels for interrogation.

FUNCT - These systems are used to assist in the automatic or semiautomatic detection, location and identification of the suspended cable structure to allow searching vessels to home onto the facility; to provide a geographical point of reference for vessels to assist in navigation; and to alert vessels to the existence of the facility to avoid collision.

INTER - The equipment used for navigation, warning, and communications systems interfaces primarily with the structure which must support it. This generally means the Payload Accommodations (SC-400), but in the case of submerged navigation aids, it may also involve supports on either the Anchoring System (SC-100), Primary Structure (SC-200), or Buoyancy Elements (SC-300). There are also interfaces between equipment used in these systems and compatible equipment used on ships or shore stations. Energy using equipment such as lights or electronic gear, unless equipped with self-contained energy sources, will interface with Power Sources (SC-610), Controls (SC-620), and Power Distribution (SC-630). Depending upon the type, the equipment may also interact with the environment and may require protection against environmental effects. In particular, it may be necessary to consider the effects of fouling and motions of the facility and localized spray effects.

SC-710 ACOUSTIC

DESC - Acoustic systems consist of various kinds of sound-producing, sound-receiving, and sound-reflecting devices. These systems include bells, transponders, pingers, and reflectors. Some transmit identification codes and others require special codes for activation.

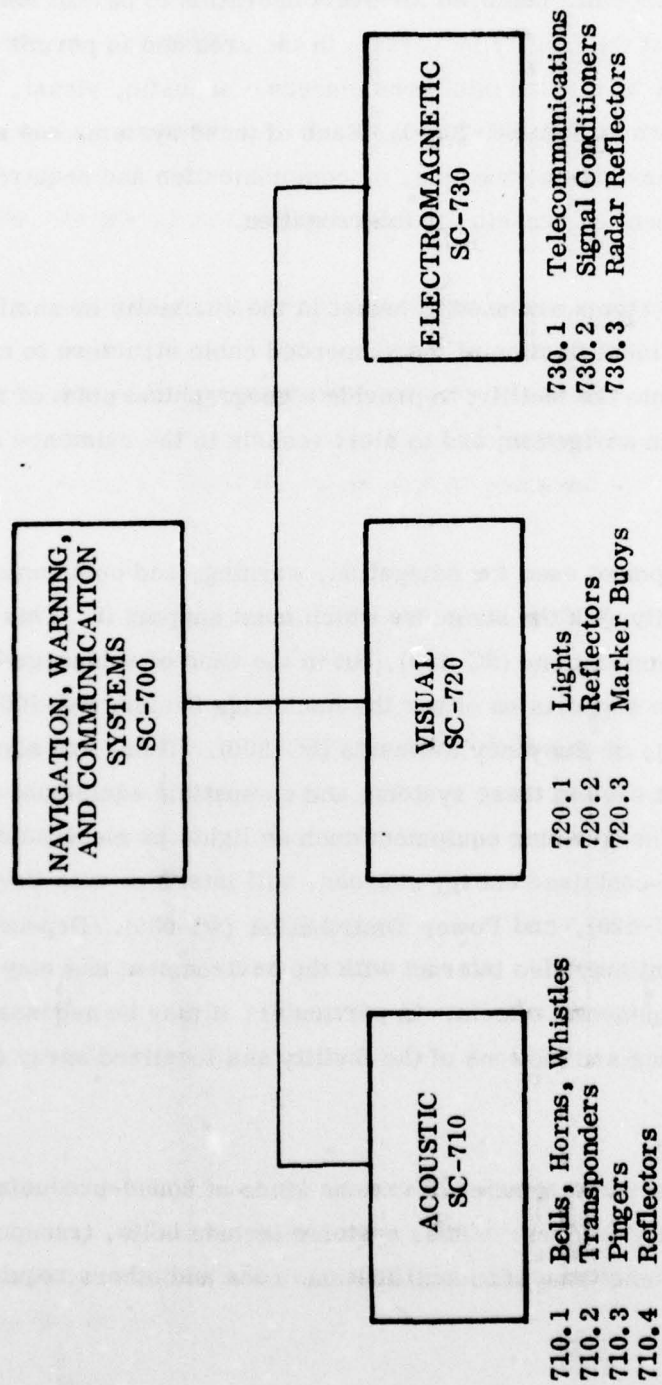


Fig. SC-700-1 Navigation, Warning, and Communication Systems -
Breakdown Structure

FUNCT - Acoustic systems receive and/or produce acoustic energy for activation of equipment, warning, or communication.

INTER - Active elements of acoustic systems are mounted external to the structure and interface directly with the Structure (SC-100, SC-200 or SC-300) where they may be a part of Payload (SC-400). Because these elements are exposed to the complete ocean spectrum, they must be protected from or be compatible with the environment. Devices that require electrical power and have an integral power source will require penetrators and cables associated with Power Distribution (SC-630).

SC-710.1 Bells, Horns, and Whistles

DESC - Bells are mechanical devices producing sound by the impact of a clapper against a resonant member. Bells are usually activated by natural movements of the sea or by disturbances caused by passing vessels, and are generally attached to surface buoys or floats. They may also be used underwater. Horns and whistles are usually air operated, the air being, in some cases, stored compressed and in other cases expelled by natural sea motion.

FUNCT - Bells, horns, and whistles are primarily used as warning devices where natural energy is available or where the energy from disturbances of passing vessels can be used instead of power sources, electrical or mechanical.

INTER - On suspended cable structures, bells, horns, and whistles are used in conjunction with the buoyancy elements, either Surface Floats (SC-310) or Subsurface Floats (SC-320). They require mechanical movement and will normally be exposed to the environment. Provisions must be made to prevent fouling or corrosion interfering with the action.

SC-710.2 Transponders

DESC - Transponders are comprised of a receiver, in some instances a decoder, and an acoustical transmitter. The receiver may respond to a narrow range of frequency or a broad range of frequencies. The incorporation of a decoder requires that a pattern of frequencies or sound pulses of some predetermined format be received before the transmitter is activated. The transmitter may respond in code to provide

identity for a location. In some circumstances, the signal may be used to actuate devices other than the transmitter.

FUNCT - Transponders respond to an interrogating acoustic signal of a predetermined format to actuate some other device such as a Payload (SC-400) or to produce an acoustic response or warning or communication.

INTER - Transponders require electrical power and must be compatible with the Electrical Power Systems (SC-600) and must have an integral power supply. Frequencies must be selected for optimum performance of the desired function. As the frequency is increased, the precision of location is improved but range is reduced. Conversely, as frequency is reduced, range is increased and precision is reduced.

SC-710.3 Pingers

DESC - A pinger is a device that produces pulses of acoustic energy at a predetermined frequency and on a specified schedule.

FUNCT - Pingers produce acoustic energy for identification, location, or warning of the presence of a suspended cable system. They may be used as markers during the emplacement of suspended cable systems or elements thereof.

INTER - When used as temporary markers, pingers will have integral power supplies that provide power during the useful life of the device. Where pingers are mounted on the Structure (SC-200) or Buoyancy Elements (SC-300) and must operate over a long period, connection to the Electrical Power System (SC-600) may be required.

SC-710.4 Reflectors

DESC - A reflector is a device that causes acoustic energy to be reflected rather than transmitted. Reflection efficiency increases as the discontinuity of density increases. Some reflectors are constructed to return a predominant amount of the reflected energy in the direction of the source.

FUNCT - Reflectors provide a passive means of enhancing the acoustic cross section of the suspended cable facility so that it may be more easily found or more easily detectable by sonar systems.

INTER - Reflection efficiency increases as the density discontinuity increases and also as the size of the reflector increases. The primary interface on a suspended cable structure would normally be on a Primary Structure (SC-200) or Buoyancy Elements (SC-300). Since reflectors are passive, they do not require power.

SC-720 VISUAL

DESC - Visual systems consist of both passive and active components that are attached to the surface elements and that utilize the visual energy spectrum. Passive components consist of surface treatments in the form of paints or other materials arranged in such a way as to maximize the changes of observation. Active components include light beacons utilizing gas discharge lamps or incandescent lamps. Range of visual devices varies from a few feet in heavy fog to several miles.

FUNCT - Visual systems either reflect or emit visual energy as a means of identifying the existence of a suspended cable structure.

INTER - Since transmission of light under water is extremely limited, visual systems are usually used above the surface. Range is a function of the specific colors and surface irregularities of the materials used as well as the visibility at the time. Range can vary from zero at night and in fog to several miles on a clear day. Passive systems, such as paint and reflectors, interface with Surface Floats (SC-310); active systems interface with Electrical Power (SC-600).

SC-720.1 Lights

DESC - A light is a source of visual energy which may be incandescent or gas discharged and may be continuous, rotated, or flashed.

FUNCT - Lights provide a visual indication for warning of the location of the surface elements of a suspended cable system.

INTER - Since suspended cable systems have limited power availability, a pulsed gas discharge lamp would probably be used. Lights would be mounted on a Surface Float (SC-310). Because of the high power requirements of incandescent lamps and rotating devices, lights for suspended cable structures would probably be intended for night operation. Care should be taken to minimize reduction of efficiency by fouling or spray.

SC-720-2 Reflectors

DESC - Reflectors are passive devices that return light to the direction of its source. They are usually lenses with highly reflective coatings that are designed to introduce color or to respond in a specific manner. Reflectors are a low-cost, highly reliable means of enhancing the visual response of surface elements.

FUNCT - Reflectors provide a passive visual indication of the existence of a buoy, and are primarily for night operation.

INTER - Reflectors are attached to Surface Floats (SC-310) and should be sufficiently above the water to reduce the effects of spray and fouling, which reduce efficiency.

SC-720.3 Marker Buoys

DESC - A marker buoy is a floating object that can be attached to a suspended cable structure. It can be of any form from a simple float to a large fabricated structure, depending upon the requirement.

FUNCT - Marker buoys provide daylight visual indication of the existence of a suspended cable structure.

INTER - Marker buoys are visually a part of or integral with Surface Floats (SC-310). Structures may be built upon the surface floats to enhance visibility. Marker buoys may be painted for visibility and Protection (SC-500), and would probably be connected to the Primary Structure (SC-200).

SC-730 ELECTROMAGNETIC

DESC - Electromagnetic systems are comprised of beacons, reflectors, and transmitters that may be active or passive and transmit data through cables or over radio links.

FUNCT - Electromagnetic systems provide electromagnetic indication of the presence of suspended cable structures or transmit data to or from the suspended cable structure.

INTER - Electromagnetic systems should be on the surface and will interface primarily with Surface Floats (SC-310). Active systems will interface with the Electrical Power Systems (SC-600); data systems may interface with the Payload (SC-400).

SC-730.1 Telecommunications

Telecommunications include radio frequency transmitters, receivers, and associated antennas or transmission systems. Also included are warning beacons, which consist of either pulsed or continuous wave transmitters and which transmit automatically or when interrogated. Interrogation may be within a wide band of frequencies, depending upon the requirement.

FUNCT - Telecommunications transmit data from or to a suspended cable structure and provide an electromagnetic indication of the existence and/or the location or identity of suspended cable structures. Transmission can be either into the suspended cable structure or beamed to the atmosphere.

INTER - For transmittal from the suspended cable structure, data can be received for Signal Conditioners (SC-730.2), and will be transmitted over Electrical Cables (SC-630.1) or antennas attached to Surface Floats (SC-310). When data are received, electromagnetic energy will be absorbed by the antennas and transmitted to Signal Conditioners (SC-730.2), or it will be received from Electrical Cables (SC-630.1) and sent to the elements of the facility through Signal Conditioners (SC-730.2).

Warning beacons are usually mounted on Surface Floats (SC-310) and require connection to a power source and the Power Distribution System (SC-630). Care should be taken to design the antenna to minimize the effects of salt spray and the environment.

SC-730.2 Signal Conditioners

DESC - Signal conditioning equipment is basically electronic. It may be housed in racks with panel construction for use in large structures or may be housed in containers underwater. It is primarily solid state and may consist of integrated circuits. Power input ranges from a few watts to hundreds of watts.

FUNCT - This equipment combines, converts, modifies or stores electrical signals so that the signals may be transmitted, processed, analyzed, or used for control.

INTER - Signal and impedance levels between elements must be carefully analyzed. Appropriate dynamic range in all elements must be provided to accommodate the range of signal levels that may be encountered. Power supplies must not introduce noise. Protection from electromagnetic interference must be considered for sensitive circuits.

SC-730.3 Radar Reflectors

DESC - Radar reflectors may be of angular metal construction encased in a radome or exposed to the environment. A corner reflector has the characteristic that it will return energy in the direction from which it was received. Reflectors may be dielectric lenses to provide enhanced radar cross section.

FUNCT - Radar reflectors provide a passive indication of the existence or location of the surface elements by returning a large portion of the energy received from the illuminating electromagnetic radar source.

INTER - Reflectivity depends upon the size and the design of a reflector. They have lightweight construction but have a large surface area. Surface floats must therefore be designed to support massive devices which may assume added weight when operating in icy environments.

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